THE POPULAR SCIENCE MONTHLY

THE POPULAR SCIENCE MONTHLY

EDITED BY

J. McKEEN CATTELL

VOLUME LXXVII

JULY TO DECEMBER, 1910

NEW YORK
THE SCIENCE PRESS
1910

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THE SCIENCE PRESS

11568

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA

THE
POPULAR SCIENCE
MONTHLY

JULY, 1910

A NATURALIST IN THE STRAITS OF MAGELLAN[1]

By Dr. CHARLES HASKINS TOWNSEND
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IT was in January and February of the misty Antarctic summer that we lingered for a month along the seven hundred miles of Magellan Strait and Smythe Channel. The delicate flowers of a December springtime were passing out of bloom giving place to flowers of longer duration, and young land birds were all out of their nests.

The uneven plains of eastern Patagonia and Tierra del Fuego were green with grass and low shrubbery and the mountains along the western channels dark with unbroken forests of evergreen beech. Our course along salt-water passages was marked by somewhat gustier weather than would have been found a short distance inland, but it was not uncomfortably chilly for explorations ashore in daytime, and days are long in summer at fifty-three degrees latitude, both south and north. It was in fact pleasanter in the straits than we had found it shortly before at Montevideo and Buenos Aires—a thousand miles nearer the tropics—where "pamperos" had been blowing wildly along the great river.

It was pleasant to escape from the unfriendly South Atlantic and enjoy the easy progress of a vessel on even keel. Still more agreeable was the panorama of passing shores and the abundant animal life of the channels and their islands. Best of all were the intimate observations of the aspects of nature, permitted by our daily explorations on land, the *Albatross* always within reach as a home camp, anchored in some protected harbor.

To the naturalist a voyage of exploration through the Straits of Magellan is a rare privilege, not only on account of the strangeness of its animal and plant life and the wonders of its scenery, but also because of the records of scientific discovery associated with it. We were following in the wake of Darwin and the *Beagle,* although more than half

[1] Illustrated by photographs made by Mr. Thomas Lee and the writer.

U. S. S. ALBATROSS IN BORJA BAY. Straits of Magellan.

a century later, and had read the quaint descriptions of the region by Magellan, Drake, Cook and the hardy sea explorers who followed them.

Out in the straits whales, porpoises and seals made their presence known at times, but sea birds were more constant objects of interest. The nesting places of cormorants were marked by masses of black-backed, white-breasted birds, acres in extent. From low island levels Cassin terns rose in clouds of protesting thousands when our boats grounded.

"Steamer" ducks[2] kept well ahead of the active oarsmen, their flightless wings aiding their webbed feet in a manner suggestive of paddle wheels used as auxiliaries to screw propellers, trailing a foamy wake a hundred yards behind. The species belongs exclusively to southern South America and is altogether the most notable bird of the straits region. It is said to weigh over fifteen pounds. While it can not, or at least does not, fly, and is seldom inclined to dive, the rapidity of its progress over the surface long ago attracted the attention of explorers and navigators. Most observers are of the opinion that the wings move alternately when in motion. An occasional penguin—that flightless, burly diver, peculiar to Antarctic seas—only showed himself above water in porpoise-like leaps and was seldom easy to get.

The diving petrel,[3] also Antarctic in range, was by special request a mark for all guns, but no specimens were taken. As a quick diver it

[2] *Tachyeres cinereus.*

[3] *Pelecanoides urinatrix.*

is a little brother to the northern auklet, which it resembles in appearance and to some extent in habits. When at large there is nothing in its actions to suggest the petrel. It strikes down into the water from full flight, emerging farther on, fairly bursting forth into the air with wings in rapid motion.

There were also gulls, jægers and grebes along the great waterway. Albatrosses and Cape Horn pigeons did not follow us into the straits, but we found them awaiting the ship when we emerged into the Pacific a month later.

About the marshy places, ducks, geese, plovers and snipes of unfamiliar kinds afforded sport as well as ornithological specimens on our trips ashore. The Paraguay snipe proved a good substitute for the Wilson snipe of North America. Most striking in appearance were the large kelp geese, the males of which are snowy white and the females dark.

The barred Magellan geese, however, are more important on account of their abundance. This bird is a resident of the region throughout the year. It is an inhabitant of the open plains and mountain slopes and is a land rather than a water species. It occupies the open country of Tierra del Fuego in enormous numbers and has contributed more to the food of the white settlers now establishing sheep ranches in that country and in Patagonia than any other wild creature.

With few exceptions both land and water birds were species of the southern hemisphere and of Antarctic distribution.

The Magellan robin would have passed for the North American bird but for its gray tones and its disinclination to sing. There were

NATIVES. Straits of Magellan.

wrens, swallows, finches, flycatchers and hawks to be seen daily, but all in unfamiliar guise.

The Great Magellan owl was enough like our great horned owl to be taken for the same bird. The same might be said of two pygmy owls shot at Laredo Bay, which closely resemble those of our western states and are among the smallest of known owls. The Magellan pygmy, notwithstanding the abundance of its fluffy plumage, is a mere featherweight of less than four ounces. The burrowing owl and spar-

GLACIER ICE. Ayre Sound, Straits of Magellan.

row-hawk did not differ appreciably from home species. In these latitudes the burrowing owl inhabits excavations made by the "viscacha," a rodent of the chinchilla family which lives in communities after the manner of our northern "prairie dog." Lacking the viscachas' burrow, it digs its own. The common barn owl and short-eared owl of world-wide distribution were both present.

Kingfishers, woodpeckers and goldfinches were masquerading along the straits in strange garb, and best disguised of all, a meadow lark with bright crimson breast.

A courageous species of humming-bird[4] penetrates southward into the chilly wilds of Fuegia, and we procured specimens within a few hours of a snow squall which greeted us in one of the western channels. The Patagonian burrowing parrot we found within a few miles of Punta Arenas, where it seemed as much out of place in the driving mist as it would in Alaska.

In the dense forests along Smythe Channel we heard and obtained

[4] *Eustephanus galeritus.*

the "barking bird,"[5] a thrush-like ground bird whose sharp notes suggest the presence of a small dog. The condor and buzzard were frequently seen.

One of the most interesting of the birds is the quail-like *Attagis,* a species of the Limicolæ inhabiting the open uplands. Darwin refers to their rising and flying like grouse and says they occupy the place of ptarmigan of the northern hemisphere.

The most familiar bird of the straits is a species of creeper[6] which follows the hunter constantly through the forest. The Cape Horn wren is as saucy as a wren can be, and the marsh wren creeping through the grass like a mouse, is almost familiar enough to be caught with a butterfly net.

Of the hundred or more species of birds to be found along the straits we obtained about seventy, three of which belonging to the family of "wood-hewers"[7] were new to science. Our bird collection numbered one hundred and seventy specimens in all. The variety of migratory birds was greater than we had expected, but South America has a wonderfully varied bird fauna, and why should not the migrants fly southward in springtime if summer is to be found in that direction? One has but to get used to a reversal of the seasons.

The natives had skins of puma, guanaco, deer and Patagonian ostrich, but none of these were observed alive, as our shore trips did not permit of extended journeys inland. The Magellan fox, otter and little striped skunk were easily obtained, the last going whole into a tank of alcohol sent ashore for the purpose, no one being sufficiently self-sacrificing to skin it. We could only hope that the alcohol would have a deodorizing effect, but I never had the courage to inquire of the curator of mammals of the Smithsonian Institution respecting an alcoholic specimen of *Mephitis patagonica* from the Straits of Magellan.

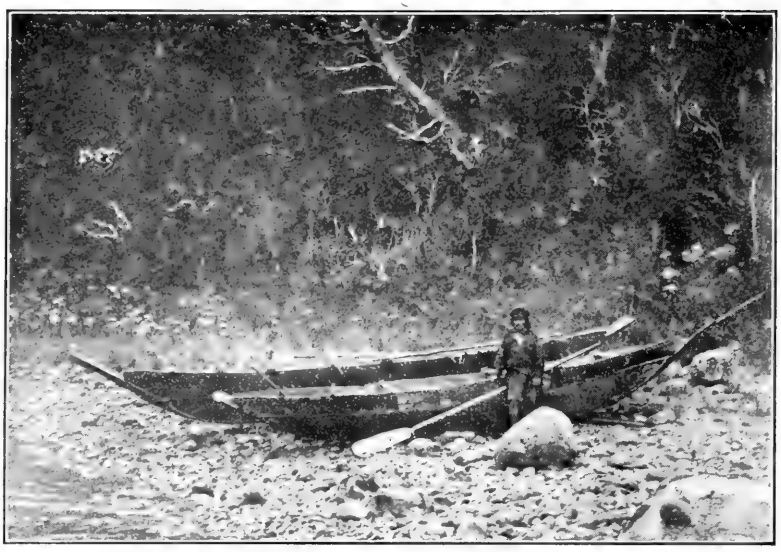
The inquisitive fox watched us everywhere from the bluffs, but the crab-eating otter quickly slid from the rocks into the tangles of giant kelp so abundant along the shores of this region.

From Punta Arenas a two days' journey was made in the steam launch to the Fuegian side in search of Antarctic fur seals. We met with these animals about thirty-five miles south of Punta Arenas, at St. Peter and St. Paul Rocks, where a number were lying on the rocks near the water. By landing on the opposite side the captain and I managed to stalk them, killing three with our Winchesters before they could take to the sea. After the seals had been skinned for museum specimens, the carcasses were eagerly appropriated by a canoe load of hungry and more than half-naked Fuegians. While the men were stowing their wind-fall of fresh meat in the canoe, one of the women went foraging among the nests of some cormorants near by, taking all

[5] *Pteroptochus.*

[6] *Oxyurus spinicauda.*

[7] *Dendrocolaptidæ.*



FUEGIAN CANOES. Straits of Magellan.

the half-grown young she could carry, staying her appetite meanwhile with such raw eggs as could be found. Another woman was busy at the characteristic occupation of baling, for all Fuegian canoes leak, not being dugouts, but made of the roughest of native-hewn slabs lashed together with tough vines or rootlets and caulked with mosses. A third woman and a child seemed to be warming food over a fire and incidentally warming their own nearly naked bodies. The party had no knives and borrowed one of ours to cut up their meat.

Their backs were partly protected by guanaco skins, tied around their necks with the hair side out. These primitive capes were not otherwise fastened and, when the hands were in use, left the body quite exposed to the wind. None of the canoe Indians that we saw had more clothing, except in a few cases where they used portions of cast-off sailor clothes, and none fastened their fur capes about the body with so much as a string.

There is always a low fire burning on a bed of earth in the bottom of the Fuegian canoe wherever it may be met with, making possible the serving *en route* of smoked cormorant and baked mussels, but the indications did not always point to that use of the fire, some of the food at least being eaten raw. It is doubtless necessary for these wandering shellfish gatherers to maintain a permanent camp fire; to light it anew on their rain-saturated shores must tax their ingenuity to the utmost. A careful search of the canoes revealed neither flint nor matches, and the Fuegian has no pockets. This was our first meeting with the canoe Indians. Later we encountered them among the western channels, but never more than two canoes could carry. They were always eager to come aboard the ship and to trade their bone-pointed spears, bows and

arrows, or rough paddles for ship biscuit and misfit clothing. They were even willing to trade their children. The canoe was apparently the only article not for sale. It seems to represent home and fireside, the few brush and leaf-covered bowers we saw on shore being merely hastily made night camps and wet ones at that. The canoe conveys the people from mussel bank to sea-bird rookery in the continual search for food. It is not likely that they often get seals, as their spears appear too rude—merely short poles with the bark on, the bone points being tied on in the roughest manner. Besides there never seemed to be enough seal skins to provide each member of the group with a cover for his shoulders. Naked children huddled close to their mothers for shelter from wind and rain. We made no measurements, but my recollection is that none of these savages exceeded five feet in height. The faces of the adults were all utterly barbarous. We saw but one dog among these people, where he may have been of more importance as possible food than as an aid in the capture of food. It is not unlikely that the natives get plenty of young seals during the season when the animals are breeding on the outlying rocks.

In Punta Arenas I purchased from a trader a rough Fuegian basket, but did not ascertain from what tribe it was derived.

Our photographs show Fuegians with clothing, but we had supplied it. We had at last found primitive man. It is doubtful if he exists in greater simplicity anywhere else to-day.

The natives of Fuegia are quite different from the Patagonian tribes and are known as the Onas, inhabiting the interior of Tierra del Fuego proper and subsisting largely by the hunt of the wild guanaco;

FUEGIANS. Otter Bay, Straits of Magellan.

the Yahgans of the Cape Horn region and the more southern parts of the archipelago, and the Alaculofs of the western channels, who like the Yahgans, are canoe Indians. All are disappearing in the face of the long, irregular warfare maintained between themselves and the white race. In half a century they have diminished from perhaps forty or fifty thousand to certainly less than one thousand. It is to be regretted that the canoe Indians have not been the subject of more study by ethnologists, as they probably are the least known of wild tribes, and the lowest in the scale of intelligence and development.

In the vicinity of Punta Arenas, which marks about the first third of the westward journey through the straits, the general aspect of the country undergoes a change. Hills and patches of forest appear. The climate also changes appreciably, the western part of the region being much more stormy and rainy. From this neighborhood may be seen to the southward on clear days the white summit of Mt. Sarmiento, nearly one hundred miles away. It is 7,000 feet in elevation —the highest peak in Tierra del Fuego—and its summit is as yet untrodden by man. Sir Martin Conway succeeded in reaching a height of only 4,000 feet when his party was driven back by appalling storms of sleet.

The resemblances to northern species which were noticeable among many of the birds, were traceable among the wild flowers. There were dandelions, buttercups, ground orchids, anemones, yellow violets, geraniums, gentians, yellow star-grass, primroses and marigolds, and probably hosts of others not observed because not in bloom. Many of those met with are unfortunately not namable except in botanical terms. Growing close to the ground and very striking was a large pink flower[8] of great beauty common along the western shores. There were ferns of many kinds. A barberry shrub[9] was found everywhere, and a fine currant bush[10] was often seen. Our greatest surprise was at the size and beauty of the *Fuchsia,* which forms thickets ten or twelve feet high and bears a wonderful abundance of flowers much frequented by humming birds.

The contradictions presented by nature were remarkable: with cold rain storms blowing over the mountains and beating fiercely down into the channels, chilly mists and lowering skies perhaps most of the time, we must yet believe it summer where, at the same time, humming birds, parrots and flamingoes, beautiful flowers and ripe berries are to be found. The line of perpetual snow is only 2,000 or 3,000 feet above tide water, while the mean summer temperature is about 50 degrees.

However mild and bright occasional days might be, the forests were always damp to the point of saturation. The excessive moisture

[8] *Philesia buxifolia.*

[9] *Empetrum.*

[10] *Ribes magellanicum.*

was favorable to certain large fungus growths on the trees, and used as food by the natives.

The chief constituents of the Magellan forest are the Antarctic beech,[11] the evergreen beech,[12] and the "winters bark[13] (of the magnolia order) with laurel-shaped leaves nearly four inches long. A so-called cypress[14] is conspicuously abundant along the western channels.

It was new and rich ground for the scientific prospector. The naturalists were not to be deterred by the weather, but penetrated the narrow side channels in the ship's boats, shooting, fishing, botanizing, shore-collecting at low tide, photographing, hammering mesozoic fossils from the rocks, digging in the ancient shell-heaps of the aborigines and bartering with the natives.

Suitable beaches for dragging the seines were not easy to find, but the sailors usually secured enough smelt and mullet-like fishes for the table and a considerable variety of finny oddities for the ichthyologist's alcohol tanks. The naval officers found sport for their trout rods, in taking a trout-like fish abundant in the small streams. They insisted on calling it a trout, but this peculiar genus, *Haplochiton,* of the austral fresh waters differs noticeably from the boreal fish in lacking the adipose fin of the true trouts. To the angler it is equally gamy. The ichthyologist ignoring the rules of the true sportsman, swept many of the best pools with his nets. His "specimens," it is needless to relate, did not appear upon the mess table, much to the protest of the anglers.

Collecting along shore at low tide yielded many interesting invertebrates. A univalve of the genus *Concholepas* clings to the rocks like a limpet. It is as large as a man's fist and deep enough for a drinking cup. I saw one in a canoe where it may have been used as a boat bailer. It is also said to be used by the natives as food. The large Chilian mussel[15] is abundant and seems to be the principal item in the food supply of the natives. We found it excellent eating and obtained specimens fully seven inches long. The handsomest sea shell of the straits is *Voluta Magellanica,* which reaches a length equal to that of the large mussel.

The most interesting crustacean was an isopod of the genus *Serolis,* which bears a superficial resemblance to the extinct trilobites and here takes the place of our North American horseshoe crab[16] as a notable zoological type. We obtained specimens of it in many localities along shore and also in our dredge hauls.

We were scarcely prepared to find frogs in this latitude, but four

[11] *Fagus antarctica.*
[12] *Fagus betuloides.*
[13] *Drimys.*
[14] *Libocedrus.*
[15] *Mytilus chilensis.*
[16] *Limulus polyphemus.*

very small specimens, representing three species, were secured, one of which proved to be new to science.

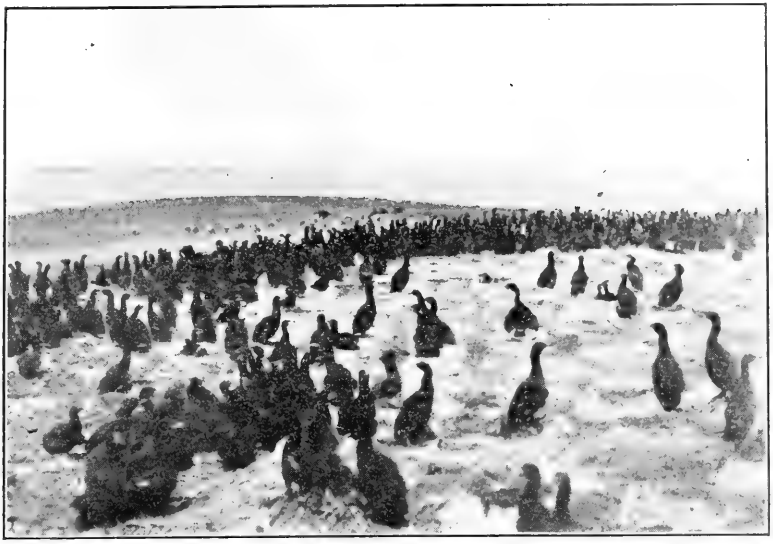
Of insect life we learned little, and our collections were unimportant. A few butterflies, moths and bees were seen, while beetles were more noticeable. Mosquitoes may be dismissed with the remark applied to the snakes of Ireland: there are none.

No exploring ship ever carried a more industrious scientific staff; its store of zoological and botanical plunder grew daily and the laboratory lights burned into the small hours for the identification of species and the preservation of specimens. The naval corps and the sailors also warmed up to the work, bringing in birds, mammals, fishes

CASSIUS TERN. Straits of Magellan.

and plants, some of them wielding the clumsy coal shovels from the fire-room, in digging ancient stone and bone implements from the shell heaps. Some of the shell heaps or "kitchen middens" as the archeologist called them, were several feet thick. Digging into them was laborious and the results called forth only contemptuous remarks from the sailors. A few arrow-heads, bone, flint and stone implements with bones of seals, and mussel and limpet shells did not seem to them worth the effort. But the ancient camp sites showed to those who could read their story, that the native population of the past had lived as simply as their descendants of the present, had subsisted on the same food, used the same primitive tools and camped on the same spots. There were doubtless more of them as barbarians decrease in numbers after contact with the white race.

Large mammals were, with the exception of fur seals and Antarctic sea lions, not common along the line of our operations, but foxes, otters, coypu, *Ctenomys* and other small fur bearers of the far south



STRAITS OF MAGELLAN. White-breasted cormorants. Santa Marta Island. Young birds in foreground.

were added to the ship's steadily increasing lists of the fauna and flora of the straits.

In the captain's private log there is a reference to the activities of the scientific staff, in connection with notes on very stormy weather at one of our anchorages, where it was too rough to send boats ashore:

It was fortunate for the naturalists, for it gave them a chance for a much-needed *rest*—they ceased work in the laboratory at 11:30 P.M. and were off at 4 A.M. the following morning!

But the latter hour did not mean starting before daylight, at that

WHITE-BREASTED CORMORANTS, Santa Marta Island. Straits of Magellan.

season and in that latitude, and the naturalists did not consider that they were making any sacrifices.

The weather during our "midsummer" month in the straits was of all sorts: it was very rainy or misty six days, very windy as many more, slightly snowy two days, really bright and pleasant four days. The remaining days could not well be classified, presenting all of the above-named varieties of weather in such rapid succession that the entries in the log book by each watch included them all, with an occasional fierce squall thrown in to take the kinks out of the cable and give the anchor something to do. The vessel sheered alarmingly as the squalls changed direction, but fortunately they were of only brief

EXPLORING AN ANCIENT SHELL HEAP. Elizabeth Island, Straits of Magellan.

duration. With all these wintry contrarities in the season of summer blooms, it was seldom squally enough to drive the hardy humming birds away from the fuchsias.

Our shore work, beginning at Dungeness Point at the eastern entrance of the straits, covered the territory adjacent to seven different anchorages in the straits proper and six among the channels of western Patagonia, terminating finally at Port Otway, where we entered the South Pacific Ocean. With the exception of Punta Arenas, these points were uninhabited save for the occasional presence of roving canoe Indians.

At Elizabeth Island there were excellent opportunities for the observation of water birds. A rookery of Cassin terns occupied several acres, the nests being close together, so that care was necessary to avoid stepping on them. Eggs and young birds covered the ground and countless thousands of old birds swarmed close overhead, actually clouding the sky, while the noise of their cries was tremendous in volume. The adjacent island of Santa Marta was largely occupied by white-breasted cormorants, the area covered by their nests being several acres in extent. The nests, about six inches high by eighteen in

diameter, were placed close together. The great mass of old birds remained by their nests until cameras could be brought into play at a distance of fifteen or twenty yards. On being approached closer they shuffled off, not taking wing until more closely pressed, leaving the well-grown young behind. The latter had not developed the white breasts of the adults and were quite fearless. Another species of cormorant lacking the white breast, had nests along the low cliffs, while eggs and young of gulls were abundant on some elevations near the water.

Our explorations were not confined to the shores; when the ship was under way, the large dredge, or beam trawl, was often lowered to drag on the bottom, once as deep as 370 fathoms. It was, in fact, dragged systematically through the inland passages of the straits and Smythe Channel from Cape Virgins on the Atlantic to Port Otway on the Pacific. This big iron-framed net, hauled by steam power, brought up fishes, shells, crustaceans, sea urchins, starfishes and many other sea forms whose scientific names are here somewhat out of place.

Among the fishes we often got *Macrurus,* that strange, big-eyed, long-tailed genus distributed nearly everywhere over the ocean floor. Crustaceans were better represented in the dredge hauls, many deep sea types being brought up. Mollusks were plentiful in number and variety, living brachiopods—the "lamp shells" so well known as fossils—appearing frequently.

There were many specimens of small octopus and a couple of burly squids nearly six feet long. The deep-water species were, as a whole, new to science.

This whole region is an anciently depressed, sea-engulfed mass of mountains among which the voyager of the present carefully gropes his way.

The navigation of the straits is confined to daylight work and the summer days are of course long, but even then heavy fogs have to be reckoned on. The short nights were always passed at anchor. While the straits are several miles wide in places, there are dangerous narrows which can only be passed at slack water. English Narrows are less than a quarter of a mile wide and the channel affords room for but one ship at a time.

The only settlement worthy of mention here is Punta Arenas, the most southerly town on the globe. The region is too far south for agriculture, but garden vegetables can be grown in sheltered places. There is some gold digging carried on, but sheep raising has become an established industry. There was much in the climate to remind me of the Aleutian Islands, which lie nearly in the same latitude in the north.

Our observations of water temperature in the straits varied from 47° to 57° Fahrenheit, the higher temperature being found in the

more northerly channels. The temperature of the air followed in a general way that of the water.

While there was a great deal in the way of birds and flowers to suggest familiar objects, our surroundings in other respects were strange. The trees of the forest, the smaller forms of sea shore life, the utterly barbarous look of the natives, the wildness of the scenery, left strong impressions. Even the constellations were altogether unfamiliar. The navigating officer pointed out the Southern Cross, the beautiful nebulous mass called the Cloud of Magellan, the "Coal Sack," that dark starless area close to the Milky Way, and the bright stars Canopus and Achenas.

I know of no more forbidding headland than Cape Froward, the southern point of the continent. The scenery reminds one in many ways of the inland passage of Alaska and is probably finer, as there are more high cliffs of exposed rock. As in Alaska, the vegetation of the forest comes uniformly down to sea level, and here we find it actually overhanging and touching the surface at high tide.

After passing through Magellan Straits and turning northward into Smythe Channel and the series of inland passages beyond, the channels become narrower and the scenery wilder. The evergreen coniferous forests of the north are here replaced by evergreen beeches, which give a new and strange aspect. There are, however, the same high, tumbling waterfalls in the foreground with snow-topped ranges beyond.

No ordinary description can convey a clear idea of the generally impenetrable character of the forests, which are more tangled and difficult than those of the tropics. Fallen trees and branches cover deeply the whole forest floor, these in turn being mostly concealed with mosses and large plants, the whole always saturated as if by a recent rainstorm. After clambering over decayed logs, heavily blanketed with mosses, one may land waist deep in boggy vegetation. Progress is possible only by constant and laborious climbing over obstructions.

In this western section of nearly four hundred miles, the open ocean is seen only once, so completely is the long stretch of coast protected by the lofty islands of the archipelago. Passing gradually northward, glimpses of lofty snow ranges become more frequent, and at the mouth of the last narrow channel the white Andes are exposed to full view and may be enjoyed during the forty-mile voyage across the Gulf of Penas.

Before leaving Eyre Sound we made fast to one of the small icebergs drifting away from adjacent glaciers terminating in tide water, and took on board seven tons of ancient Andean ice for our voyage northward to the Galapagos Islands in the tropical Pacific.

THE FUTURE OF THE HUMAN RACE

By Professor T. D. A. COCKERELL
UNIVERSITY OF COLORADO

EVOLUTION is not an orderly march along a well-defined highway, to the slow time of the music of the spheres. In its details, it is an irregular process, sometimes so slow that millions of years seem to make no difference; sometimes so rapid that a single generation marks a notable advance. Many of its most remarkable products come into existence only to perish shortly afterwards, because they are exclusively adapted to conditions which are not permanent. Rapid progress seems usually to go with a high percentage of failures, as though progress itself were only an attempt to dodge the stroke of doom. Out of all this man, the species *Homo sapiens,* zoologically speaking one of the higher apes, has in these latter days evolved. A creature in many ways inferior to his brother mammalia, but favored by the gods. Denuded of hair, he is obliged to spend much of his time and energy providing artificial clothing; slow of foot, he is compelled to devise means of travel not depending upon his muscular activities; so deficient in the sense of smell, that he does not know, as do the dog and the ant, that it is the most important of all the senses; lacking a tail, and with no grasping power in his feet, he rarely ventures to climb the trees; a poor creature indeed, well-fitted to be the laughing stock of the rest of animal creation.

All this would not be so bad if, like his sylvan ancestors, he could go on his way with a placid sense of his own sufficiency. Alas! even this poor privilege is denied to him; in the Garden of Eden, at the very beginning of his career, he acquired the sense of sin, and was henceforth to be a wanderer in a spiritual as well as a physical sense. Hence it comes that we, in this year 1910, think it proper to enquire anxiously about the future of our species, an inquiry which would certainly never occur to any other species of mammal.

At the very outset we are bound to observe that without exception the species of mammalia are short-lived. The records of the Tertiary rocks show a continually changing panorama of mammalian life, in which genera and species come and go, while plants, mollusca and other lowly organisms remain almost unaltered. We further notice that the comparatively brief existence of these animals may be terminated in either of two ways—by extinction, or by change into something else. When the creatures are very highly developed in special ways, they

seem nearly always destined to die out, being supplanted by the descendants of simpler and more plastic forms. Supposing the career of man to resemble that of other specialized mammalia, he might be expected to have before him perhaps another hundred thousand years, and then in all probability the end of the world, so far as he was concerned with it as an animal. Even on this hypothesis, he would have as much occasion to prepare for his terrestrial future as a young child has for its adult life, but there are very good reasons for supposing that the fate of man need not necessarily be the same as that of the animals to which he is most nearly allied. Prior to the existence of man, living beings might have been divided roughly into two groups, those related to very simple or unchanging environments, such as the amœba or the oyster, and those specially adapted to complex conditions, such as the yucca moth and the giraffe. The former have proved successful through their very simplicity, have been saved by their lack of progress; the latter are nature's masterpieces, often destined, as such things are, to go out of fashion. Any single man may be taken as a rather extreme example of the latter type; he is extraordinarily dependent upon a special set of conditions, but the race as a whole is relatively independent, and without sacrificing anything of its organic complexity, is able to meet and overcome the dangers which have destroyed so many of the higher mammals. If with this man can secure a genuine but moderate progress in his fundamental organism, not sufficient to break the continuity of tradition or destroy his essential specific unity, he may be assured a career such as no mammal ever had before.

The causes of the extinction of other animals have been principally related to climate, food and natural enemies, including here the germs of disease. With regard to climate, man at first, through racial differentiation, became adapted to everything from tropical heat to arctic cold; but here he was on the way to split up into a number of distinct species. Now through devices of housing and clothing he can almost create climatic environments for himself, and so single races, or mixtures of races, are to be found nearly everywhere. At the same time, like the bird, he knows how to migrate when necessary, so that he will never be destroyed by changes confined to a single continent or even hemisphere.

In the case of food, he is relatively unspecialized, and no doubt his omnivorousness has greatly aided his spread over the globe. So long as he had to depend upon the supplies furnished gratis by nature this was a necessary condition of his cosmopolitanism; but now that he can so largely control his food supply, and can carry any given product to the opposite end of the earth, it is a question whether there will not be a distinct gain in a return to primitive simplicity in diet.

Of natural enemies, the grosser and more tangible kind, like the

lion and tiger, have in most places been destroyed; but the small insidious germs or bacteria remain with us. Through a process of natural selection, we have acquired a comparative tolerance of or immunity from several of them, but they have at all times heavily taxed our resources, and have actually been the means of exterminating many races. It is perhaps not unlikely that man would have died out before this, had he been confined to any limited region; but since his distribution has always been wider than the prevalence of any one disease, he has managed to survive in spite of all of them.

A very interesting discussion of the insidious parasites of disease has been given by Dr. Ronald Ross in an address on "Malaria in Greece," delivered before the Oxford Medical Society.[1]

Until recent times, the success of mankind in weathering the dangers of disease has been mainly due to the precautions he has been able to take, along with the limited distribution of diseases, and the process of evolution against them. In the future with the aid of science there can be little doubt that the bacteria of many will be exter-

[1] This is quoted, with much other pertinent matter, by Dr. L. O. Howard in Bulletin 78, Bureau of Entomology, U. S. Department of Agriculture (1909).

We now come face to face with that profoundly interesting subject, the political, economical and historical significance of this great disease. We know that malaria must have existed in Greece ever since the time of Hippocrates, about 400 B.C. What effect has it had on the life of the country? In prehistoric times Greece was certainly peopled by successive waves of Aryan invaders from the north—probably a fair-haired people—who made it what it became, who conquered Persia and Egypt, and who created the sciences, arts and philosophies which we are only developing further to-day. That race reached its climax of development during the time of Pericles. Those great and beautiful valleys were thickly peopled by a civilization which in some ways has not been excelled. Everywhere there were cities, temples, oracles, arts, philosophies and a population vigorous and well trained in arms. Lake Kopais, now almost deserted, was surrounded by towns whose massive works remain to this day. Suddenly, however, a blight fell over all. Was it due to internecine conflict or to foreign conquest? Scarcely; for history shows that war burns and ravages, but does not annihilate. Thebes was thrice destroyed, but thrice rebuilt. Or was it due to some cause, entering furtively and gradually sapping away the energies of the race by attacking the rural population, by slaying the new-born infant, by seizing the rising generation, and especially by killing out the fair-haired descendant of the original settlers, leaving behind chiefly the more immunized and darker children of their captives, won by the sword from Asia and Africa? . . . The whole life of Greece must suffer from this weight, which crushes its rural energies. Where the children suffer so much how can the country create that fresh blood which keeps a nation young? But for a hamlet here and there, those famous valleys are deserted. I saw from a spur of Helicon the sun setting upon Parnassus, Apollo sinking, as he was wont to do, toward his own fane at Delphi, and pouring a flood of light over the great Kopaik Plain. But it seemed that he was the only inhabitant of it. There was nothing there. "Who," said a rich Greek to me, "would think of going to live in such a place as that?" I doubt much whether it is the Turk who has done all this. I think it is very largely the malaria.

minated, and it will no longer be necessary to think of them as possible dangers to human life. Thus, in England, by the universal practise of muzzling the dogs for a sufficiently long period, hydrophobia has been eliminated; in the tropics by the quite feasible if somewhat difficult plan of destroying the mosquitoes, yellow fever and malaria may be utterly stamped out in some regions. Other diseases are much less easily controlled, but it does not appear more difficult to destroy them than it once did to get rid of the wolves in England.

Along with the development of the medical and agricultural sciences, we may hope for great advances in social organization, reducing to a minimum the tremendous waste of life and property which goes on to-day. It is not too much to expect that every individual will be assured all the air, food, clothes and shelter necessary for a normal existence, and will find ample opportunities for exercising such talents as he may possess. Liberty will be curtailed in so far as it permits antisocial activities, but it will be tremendously extended, in the form of practical opportunities to develop ordinary or special abilities. All this may be a long way ahead, and there may exist great differences as to the program for the near future; but I suppose that few will deny that some such outcome as that indicated should logically follow from indefinite advance in the direction we are even now taking.

If we picture human society thus relatively perfected, and free from many of the ills which now so fearfully decimate it, what have we left to desire? Very much, I venture to think. Is there one of us who could honestly say that, if he had been born into such a society, he would be without any serious defects of mind or body? In other words, given as good an environment as could well be devised, should we then be perfect? It is exceedingly obvious that we should not.

Those who are enthusiastic, and very justly, concerning the possibilities of social reform, are somewhat too apt to assume that all deficiencies noted in people to-day are due to adverse external conditions. The student of heredity—even the farmer, when he is dealing with his crops—knows better than that. Figs do not grow on thistles, for all the fertilizers in the country. There is no doubt whatever that every year there are born thousands of persons who are not merely unfitted to succeed in the world as it now is, but would never be successful in any complete sense in any world which could be devised or imagined. Some of those who recognize this fact see in it the doom of all social amelioration. If to-day the tremendous destruction of the unfit which takes place leaves us so many incapables, what would happen if most of those who perish were to survive? Would not society be buried beneath a load of incompetency, which would make even such organization as we have impossible? To this gloomy suggestion it may be replied, in the first place, that much of the present-day elimination is of those who

would be eminently fitted to become useful members of society, could they be saved. Those who die of bacterial diseases may be unfitted to cope with those diseases, but this does not imply all other forms of unfitness. This has been recognized from time immemorial, in the phrase, " those whom the gods love die young."

In the second place, it should be pointed out that while much of the elimination now occurring is desirable, it is no doubt preposterously haphazard, and those who so keenly recognize the need for elimination, should be the first to advocate a rational method of bringing it about. This rational method consists, not in the *destruction,* but in the *prevention* of the unfit.

At this point it will be useful to leave mankind for a while, and consider some of the recent results of the study of heredity; results obtained mainly from investigations on plants and lower animals. Without going into detail, it may be said that through the researches of Mendel, Bateson, de Vries, Davenport and many others, we have come to a very clear recognition of unit-characters in inheritance. That is to say, particular characters, such as hairiness, eye-color or susceptibility to some disease, are inherited separately, passing from one generation to another much as atoms pass without change from one to another chemical compound. These unit characters may be lost, and sometimes the loss is real and final, sometimes it is illusory, due merely to non-potency. In very simple cases, it is found that the inheritance of these units follows easily recognized laws, the distribution being in accordance with the laws of chance. In others, this is not evident, and in man especially, the results are often perplexing. Thus the mulatto is virtually a blend between the white and black races, and at first sight it is not at all apparent that the racial characters are inherited as separate units. Nevertheless, we have indications of this in the remarkable differences sometimes observed within a single family of mulattoes, and it may well be inferred that further investigation will yield results in accordance with recognizable laws, and in so far predicable in advance.[2]

The absolute distinction which at first seems to exist between characters which are inherited as separate units and those which blend may not be real. When the units are obviously separate, but are fairly numerous, they will produce every sort of mosaic, in the most confusing, and at first sight wholly disorderly manner. Let them be somewhat more numerous still and it becomes practically impossible, by mere inspection, to disentangle the result. It is just as black and white balls, if of large size, will appear as separate things when mixed, but if sufficiently small will give an apparent blend, of uniform gray. Because

[2] When two " opposing " units coexist after a cross, there not rarely occurs a blended result, due to what is called " imperfect dominance," but this does not prevent complete segregation in a later generation.

of this possibility, we are not as yet entitled to explain all blending away as illusory; but we may bear in mind that this may be the case. It can at least be said, that scarcely a month passes without some case of inheritance, formerly seeming inscrutable, being brought into the field of well-ascertained law.

With the incoming of the idea of unit characters, passes our former conception of continuous variability. Supposing every character to be at all times variable—that is in motion, as it were, away from its present center of stability—there is no doubt that continuous selection would be required to keep characters up to any particular standard. The extraordinary permanency of some organic characters should suffice to make us doubt this necessity. For millions of years, certain features in the lower animals have been handed down generation after generation, practically without change. When we remember the tremendous complexity of the protoplasm molecule and the much greater complexity of the least imaginable bearer of heredity, and the fact that it has not been possible to break up and then reform the combination, as in inorganic chemistry, the permanency of these units in time is simply amazing. Least particles of protoplasmic jelly, they have stood while the rocks have been ground to dust, and made over many times. They are entitled to be ranked among the most permanent things in nature.

What then of the facts of variability, as they appear to us? What is the use of denying continuous variability, in the face of the fact that no two human beings are alike? The paradox may be resolved, when we remember the extraordinary number of words in the English language, no two the same—yet made up of the undeniably unchanging letters of the alphabet. When we recall that, on the unit character theory, the units in man must be exceedingly numerous, and must be recombined in almost every conceivable way in bisexual inheritance, it is easy to see that the chances against any two individuals coming out exactly the same are so great that such a result is practically impossible. The only case which can come under this head are those of identical twins, where the resemblance is indeed amazing, throwing light on the extraordinary potency of inheritance. Such twins are believed to result from the division of a single fertilized ovum, and hence to be, in a biological sense, two halves of a single individual.

Much light has been thrown on the permanence of unit-characters by studies among plants and protozoan animals of what are called pure lines. A pure line is one in which all the individuals have the same ancestry, uncontaminated by crossing. The most remarkable results have been obtained by Professor Jennings in his studies of *Paramecium*.

He says:

> In a given "pure line" (progeny of a single individual) all detectible variations are due to growth and environmental action, and are not inherited.

Large and small representatives of the pure line produce progeny of the same mean size. The mean size is therefore strictly hereditary throughout the pure line, and it depends, not on the accidental individual dimensions of the particular progenitor, but on the fundamental characteristics of the pure line in question.

All this indicates that if desirable qualities, represented by units in inheritance, are once obtained, and are not disturbed by crossing, they may continue from generation to generation indefinitely, without variation other than that produced in the individual by the immediate influence of the environment.

But, here, as Professor Jennings remarks, we have to ask how the different pure lines arise? That is to say, whence the different qualities which assuredly did not all coexist in the original form of life? We have seen that the unit in inheritance is, to say the least, a very complex object from a chemical point of view. No doubt it is easily destroyed, but its usual character seems to be that of resisting molecular change short of disintegration. Thus it is carried on from individual to individual, virtually unaltered, or in the alternative cases, destroyed. Occasionally, however, it must be subjected to some subtle influence which merely disturbs its internal structure, or perhaps deprives it of something it possessed. When this occurs, we have an original variation, the starting of something really new. Such original variations must be relatively rare, and we do not know what causes usually bring them about. Tower with beetles and MacDougal with plants seem to have produced them, in the one case by changes of temperature and moisture, in the other by chemical means. The fact that in some regions certain genera produce many species, as the asters in America, the brambles in Europe, seems to suggest that the disturbing influence may be different for different organisms, and may be locally distributed. Or it may be that, a line of disturbance once set up in some unknown manner, influences prevalent anywhere are sufficient to continue the line of change.

It may be that coming generations will see the causes of original variation fully elucidated, and the phenomenon itself brought largely under control. While mankind would thus be furnished with a weapon of extraordinary value, one trembles to think of the damage it might do. It might be made the means of producing new and wonderful variations in plants and animals, even in man himself; but inasmuch as there is every reason to suppose that its results could not often be accurately foretold, there is no telling what evil might result, even supposing that the power was never used with intentionally malicious purpose.

We are not at present, however, in any danger of being overrun with original variations; and it must be remembered that most of the recent wonders of Burbank and others, which are new in a practical

sense, owe their origin biologically to recombinations of characters which have existed from time immemorial in separate races. No doubt the great men which arise in human societies from time to time may be explained in the same manner, so far as they are regarded as biological phenomena.

This possibility of producing what is virtually new by recombination must now be considered. Through the work done by various breeders, beginning with Mendel, we know much about the manner of such combinations, and how to get rid of undesirable units. Where the cases have been simple almost ideal success has been attained: and in complicated cases it has been possible to produce definite results by concentrating attention on special characters. Thus Bateson in his presidential address before the zoological section of the British Association in 1904, said:

> There are others who look to the science of heredity with a loftier aspiration: who ask, can any of this be used to help those who come after us to be better than we are—healthier, wiser or more worthy? The answer depends on the meaning of the question. On the one hand, it is certain that a competent breeder, endowed with full powers, by the aid even of our present knowledge, could in a few generations breed out several of the morbid diatheses. As we have got rid of rabies and pleuro-pneumonia, so we could exterminate the simpler vices. Voltaire's cry, "Erraser l'infâme," might well replace Archbishop Parker's "Table of Forbidden Degrees," which is all the instruction Parliament has so far provided. Similarly, a race may conceivably be bred true to some physical and intellectual characters considered good.

We come then to the conclusion that in the case of man, as with domesticated animals and cultivated plants, it is possible to get rid of many undesirable qualities, to combine others which are desirable, and to maintain indefinitely that which has been once secured. Where there is bisexual inheritance we can not have strictly pure lines, to be sure, but it is possible to have lines which are pure within practical limits. That is to say, we may have a race of people none of whom have a certain hereditary taint, all of whom have a certain hereditary quality. Beyond this, we would not go, were it possible; for no one would wish to sacrifice the interesting diversity of human types which makes life chiefly worth while. In our national aspirations, we have recognized the ideal of a moderate unity of type; thus all Englishmen will agree that a true, full-blooded countryman of theirs should possess certain attributes, and will admit that those who fail in this are not strictly of the elect. All Frenchmen, typically, should have a certain vivacity not found among the Englishmen, and so on throughout the series.

Thus the ideal of a relatively pure race of high quality is by no means a new one; but what is new is the practical knowledge of how this may be brought about, with the certain expectation of much more

light on the subject in the near future. The realization of such an ideal involves selective mating; but this again is nothing new, all mating among civilized people is selective, with a wide range of reasons for the selection. To these will now be added a new one, or rather an old one in a somewhat new light.

Professor J. Arthur Thomson well says:

> As to the diffusion of disease by the intermarriage of badly tainted with relatively healthy families, we have this in our own hands, and we need not whine over it. The basis of preferential mating is not unalterable, in fact we know that it sways hither and thither from age to age. Possible marriages are every day prohibited or refrained from for the absurdest of reasons: there is no reason why they should not be prohibited or refrained from for the best of reasons—the welfare of our race.

On the other hand, we have to consider the means of increasing and continuing good qualities. The economic burden of raising a family is at present such as to discourage many whose qualities should be continued to other generations, and there can be no doubt that it would pay society to furnish ample means for the industry of child raising to those who are especially fitted to engage in it. Mr. Francis Galton has tried to calculate the value of different classes of individuals:

> The worth of a $+\times$-class baby would be reckoned in thousands of pounds. Some such "talented" folk fail, but most succeed, and may succeed greatly. They found industries, establish vast undertakings, increase the wealth of multitudes, and amass large fortunes for themselves. Others, whether they be rich or poor, are the guides and lights of the nation, raising its tone, enlighting its difficulties, and improving its ideals. The great gain that England received through the immigration of the Huguenots would be insignificant to what she would derive from an annual addition of a few hundred children of the classes $+w$ and $+x$.

MIDDLE AND DISTANCE RUNNING

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IS middle and distance running as practised in our schools and colleges injurious or is it not? The verdict of spectators at an intercollegiate or interscholastic track meet, as the contestants cross the finish line frequently exhibiting every evidence of exhaustion, would probably be in the affirmative. It is difficult for them to resist the belief that a contest which so drains a man of his strength must, of necessity, use up vitality that can never be completely restored, must permanently weaken the heart, and perhaps injuriously affect him in other respects. This investigation was undertaken in the hope of ascertaining whether there is adequate foundation for such a belief.

In an experience extending over fifteen years, the writer has attended many track meets, has known personally hundreds of runners, has time and again questioned them in regard to their personal experience. Curiously enough, he has never found a single man who would admit that he had been injured by racing. The incompatibility between the positive assertions of these men and the popular impression as to the effects of distance running was so pronounced, and the subject is such an important one in its relation to schoolboys and college men, that an investigation became imperative. The investigation does not deal with the marathon running of the present day, but solely with the distances usually run in school and college—one half to two miles and cross-country seven miles.

Athletes from all parts of the country have been consulted, principally men who quit running years ago, and who have had ample time to note in their own persons the after effects of the training they underwent; men whose youthful enthusiasm has been sobered by years of business or professional life and whose judgment is therefore to be respected. Some of them quit running thirty years ago; others twenty-six, twenty-four, eighteen, twelve, etc. A few are still running, only eight in all. Seven have just quit, nine stopped a year ago and the great majority from two to thirty years ago, averaging eight and a half years. Nearly one half of the whole number ran for five or more years, training five to six days a week in two groups, one group averaging twenty-six weeks a year, the other ten weeks. Many trained six days a week, thirty to forty weeks a year. These men have been allowed to speak for themselves, first as to

facts, *i. e.,* the manner in which they have been affected by their running; second as to their opinions, *i. e.,* whether or not they consider distance racing and cross-country running safe and valuable forms of exercise. The facts to which they testify must be considered as final; the opinions they express, even if not accepted as conclusive, must be of greater value than opinions based merely upon theory, for they are the incarnation of living experience, formed through days, weeks and months of hard grueling work, through knowledge of the manner in which their team mates bore the drudgery of training and the strain of contest, and shaped finally by their own physical condition during the years which have elapsed since they ran.

Injuries to the Heart.—In view of the general belief that running is apt to injure the heart, particular attention was given to this phase of the question. Contrary to expectation, permanent injury to the heart was found to be very rare, only three men testifying to this effect and in these three cases the injury manifests itself only in unusual exertion. Twelve others developed functional heart affections, irregularity, palpitation, etc. Further correspondence with these men shows that all of these functional irregularities have been entirely cured. Ten of these fifteen men had what is known as "athlete's heart," three of the cases persisting to this day, as stated above.

Generally speaking, the term "athlete's heart" is very vaguely comprehended. In medicine, it is defined as compensatory cardiac hypertrophy—that is to say, it defines a heart which although it has become enlarged, still performs its functions perfectly. Such a heart is normal in an athlete or in any man who performs vigorous physical exercise, the fibers growing firmer and larger as the demands upon the organ increase, just as a man's muscles grow firmer and larger under a month's outing in the woods. In almost every instance a heart of this type will shrink to approximately its former size without injury to its tissues, after the exercise has been discontinued. When, however, a man pushes his exercise too far, his heart may develop valvular insufficiency, palpitation or other functional irregularity, and I am inclined to believe that this is what the average physician means when he tells a man that he has "athlete's heart." This was so in most of the cases mentioned above, nevertheless, all but three of the men have since been cured. "Athlete's heart" is usually a temporary condition and permanent injury from overwork is rarely found. In an experience with school boys in all branches of athletics extending over a period of fifteen years, I have met with but one case of true athlete's heart, and this boy's physician told him that if he would abstain from violent exercise for six months he would be entirely cured. This heart affection was brought about by two years of hard training for the mile, beginning at an early age. This case, together with the free expression of opinion from athletes to

whom this inquiry was addressed, strengthens my conviction that unless a boy is unusually well developed, he should not take up distance running in earnest until eighteen years of age, and leads me to believe, furthermore, that the practise of running school boys daily from the beginning of the school year in order that they may compete in the spring, is a bad one, as is also that of running them in so many races during the season.

But there was found to be a credit as well as a debit side in the effects of running upon the heart. One man writes: "My training and running caused previous heart and lung trouble to disappear"; another, "transformed a nervous heart into a normal one"; another, "transformed a heart beating 100 usually, with occasional palpitation, into a normal one and caused the palpitation to disappear"; another, "when I began running, I was so weak that I was supposed to go down stairs backward—at the last physical examination I was found to have one of the best hearts in the school. Ran four years from 440 yards up to seven miles."

Other Injuries.—In response to the question "Has racing ever injuriously affected you, and how?" eight men testify to temporary injury due to over training or to racing when in poor condition, such as weak stomach, run-down condition, nervous breakdown, etc., the bad effects lasting from several weeks to as long as twelve months in one instance. One of these men ran the half mile, mile and two miles in one afternoon several times each year of his course of four years. This, of course, was simply inviting disaster, and it is difficult to understand how any college trainer could have permitted it. This brings us directly to a statement by one of the most famous athletes this country has ever produced, namely that

> The great trouble in my opinion is the lack of knowledge on the part of trainers. The tendency is to overdo. This is particularly true of the school boy who imagines that unless he runs himself clean out every day of practise, he is not getting in the proper condition for competition. This is where he makes a mistake, and where, in my mind, he is going to feel the effects in later years.

Proper training means work suited to the strength and development of the individual, and if a man is so trained, is allowed to compete only when fit, and is fit to run when he begins training, such injuries would not occur.

Benefits.—In answer to the question, "Has it benefited you in any way?" ninety per cent. answer "Yes," five per cent. do not know whether it has or not, and five per cent. reply, "It has not." The benefits said to have resulted are in general, strengthened heart and lungs, developed a rugged constitution, cured several weak hearts, "gave perfect health and endurance very beneficial in recent years," "cured frequent headaches," "effected a complete emancipation from

doctors and medicines," etc., and the relatively minor one of increased muscular development. The usual benefits resulting from training for any branch of athletics are also emphasized, namely, regular hours and regular habits of living, how and what to eat, the incompatability of dissipation with physical stamina, the moral lesson that hard work, and that alone, leads to success. These benefits, it will be noticed, are of the kind that contribute to increased constitutional strength, strength of heart, lungs and vital organs, and are permanent in character. The almost unanimous testimony to this increase in vital strength is worthy of special note.

Cross-country Running.—Cross-country running is generally believed to be one of the best exercises that young men can take. The testimony of Mr. Joseph Wood, the headmaster of Harrow, is of particular value in this connection. He writes:

> We keep no actual record of our runners, but I have been a headmaster now for over forty years, and my experience certainly goes to prove that cross-country running does no harm but much good; second, that in long-distance racing much care is necessary. No boy should be allowed to compete unless certified as sound and fit by competent medical advisers. At Harrow we make this a rule.

As Mr. Wood implies, there is a vast difference between cross-country running, in which a man swings along at a rate well within his powers, and cross-country racing, in which he must drive himself at high pressure from three to ten miles. There seems to be a pretty well-developed opinion among the runners that cross-country racing is injurious. An intercollegiate champion, the captain of a varsity team writes:

> I have had considerable opportunity to observe the effect of track and cross-country racing on athletes in this section [the west[. I have yet to see the track man at ——— who was injured by races over the half-mile, mile and two-mile courses, but cases have occasionally come to my notice of men whose vitality was drained severely by cross-country races over five-mile courses.

Another captain and coach writes to the same effect. Information accidentally received relating to one of the eastern universities, reveals a belief among the students that the men on the cross-country squad drain themselves of vitality, and there is frequent expression of opinion to that effect from the athletes who responded to this inquiry.

Interesting Facts.—The cross-country men began running later in life than the track men, the average being 18½ years, as compared with 17½ for two milers, 17 for milers and 16 for half milers. In the latter, the percentage of heart affections was greater than with the one and two mile men. In view of the immaturity of the boys who ran in the 880 class, this is not surprising.

Two thirds of the athletes participated freely in general athletics when not in training for track—in football, baseball, basketball, tennis, hockey, gymnastics, etc., and were practically engaged in vigorous ex-

ercise for a period of five and a half years. Their statistics do not show appreciable variation from those of the one third who engaged in running only.

Naturally and yet unexpectedly the men who trained on an average of about ten weeks a year, nothwithstanding they numbered less than two fifths of the whole number, had nearly twice the percentage of injuries. In attempting to fit themselves for the strain of a distance race in such a short time, they overworked, with consequent bad effects. Curiously enough, the men who trained twenty-six weeks a year and continued running from seven to twelve or fifteen years, had no injuries at all. It might be supposed that this vigorous exercise continued for such a long time would drain their vitality. Exactly the contrary has been the case. With one exception, all claim to be more vigorous than the average man of their age, and the exception declares himself fully as vigorous.

One half of the athletes began running as schoolboys, and 78.5 per cent. made good in college, as compared with 75 per cent. of those who did not take up the sport until they entered college. Twice as many of the boys who ran only a year or two in school made good, as of those who ran three or four years. This seems to indicate that boys who begin at school, if they do not begin too young, and if they are brought along gradually, learning stride and pace and developing stamina, have a slightly better chance than even the more mature man who takes up the sport after he enters college. There is nothing surprising in this, as it requires several years to bring a distance runner to his best. C. H. Kilpatrick, winner of the American and Canadian championships, '94, '95 and '96, and until recently holder of the world's record for the half mile, began running while at school, as did also George Orton, intercollegiate mile champion for several years. Melvin Sheppard before becoming an Olympic champion was famous throughout the middle Atlantic states as a school-boy runner. It is a common saying, however, that school-boy stars usually "fall down" in college and unquestionably many runners of promise are spoiled before they get there, but, generally speaking, the school-boy star fails to develop into a college star because he has stepped from the narrow limits of school competition into the much greater range of college athletics. I am inclined to believe that unless he has been overrun, he equals in college his school records and usually surpasses them, and while the data to support it are not at hand, I should expect this to be particularly true of distance running, at which a man should get better and better the longer he keeps at it. The evidence shows, furthermore, that boys who were over sixteen years of age when they began running did twice as well after they entered college as boys who began under sixteen. Evidently the boy who begins too young is throwing away his chances in college.

Breaking Training.—One hundred and twelve athletes quit running abruptly, and all but one of them are in vigorous health to-day, apparently having experienced no ill effects, either from breaking training suddenly or from that overdevelopment of heart and lungs which is supposed to result from athletics. This seems to indicate, first, that unnecessary emphasis has been laid upon breaking training gradually and, second, that abnormal development of the heart and lungs leading to serious affections of these organs is not to be feared.

The entire physical organism is developed by training to a condition of unusual efficiency in order to meet the demands made upon it. It is generally believed that when these demands cease suddenly —through abruptly breaking training—tissue degeneration follows, inducing physical ailments of greater or less severity. There is, undoubtedly, an alteration in the tissues when the organism is no longer called upon for vigorous activity, but the theory that this change is a pathological one is not sustained by the facts, in so far at least as distance runners are concerned, save when it is aggravated by bad habits, dissipation or close confinement. It has not been sustained in my experience with school-boy athletes, for in fifteen years I can recall but two cases of indisposition after the season, both temporary, both in football men, big and full blooded, of the type that require an active life. I think it is not sustained by the experience of the vast majority of athletes graduated from our colleges year by year, who from choice or necessity engage in business activities which deny leisure for indulgence in sport, for, if so, it should by this time show negatively in the national health statistics, whereas, on the contrary, the spread of athletics in the past generation is believed to have raised the standard of national physical efficiency. It seems to me likely that the ordinary activities of life are sufficient to bridge over the transition period, especially as men who have been accustomed to a great deal of exercise, and who feel the need of it, will, as a rule, manage to get more or less of it into or in connection with their work. I am of the opinion that, save in rare instances, the development produced by college athletics is not abnormal—as is that of professional strong men, weight lifters, acrobats, etc., in whom vitality is sacrificed to muscular development—but that it is normal, and constitutional as distinguished from muscular development, for none of the college sports, except perhaps the hammer throw, develop great muscular strength. The character of the athlete's training supports this belief. He trains hard for a season or two (twelve to thirty weeks), but during the intermittent periods and the summer his exercise is much less severe, and is engaged in solely for pleasure. He works during the training season and plays in between, the mid-seasons in this way providing just the type of letting down that is supposed to be neces-

sary, so that at the close of his college career, instead of cumulative abnormal development, as in the case of the professional strong man, he has built up an evenly-balanced physical machine.

Expert Opinions.—The athletes are nearly unanimous in endorsing cross-country running (as distinguished from cross-country racing), as a safe and valuable form of exercise, but the same unanimity is not shown when we come to the consideration of distance racing—880 yards to two miles. Ten per cent. of the men oppose racing of any kind, on the ground that it involves too much strain. Eighty per cent. of them approve it, nearly one third of these, however, qualifying their approval by saying, "if not overdone, if under proper training, if sound at the start, if sufficiently mature, etc." These various qualifications, insisted upon by so many of the athletes, indicate a pretty general feeling by men who know the game, a feeling arising from their own personal experience or through observation of others, that distance racing is not free from risk except under competent supervision. Their letters indicate that without such supervision immature boys, and men physically and constitutionally weak, will take up the game; that they, as well as those who are fit to run, will train improperly and will be likely to overdo it. They insist upon a preliminary examination by a competent physician; they are opposed to the practise of running more than one hard race on the same day, a practise common among school boys, who, as a rule, have no competent trainer to advise them; they are opposed to boys taking up the game until they are seventeen or eighteen years of age, although recognizing the difficulty of setting any fixed age limit, since the strength and development of an individual must determine his fitness. Many believe that one mile should be the limit for schoolboy contests. There is a very pronounced feeling among them that school-boys generally overwork. These opinions, held by men who know, can not be disregarded in an effort to discover and set forth the facts. They point to the dangers which lie in the path of the inexperienced athlete, and which bring adverse criticism upon the sport. And yet, notwithstanding these dangers, all avoidable, it will be apparent to any one who reads their letters that they approve the sport if properly supervised, considering it in that case not only safe but of great benefit. Almost all of the men, even those who are opposed to racing, even those who sustained injury while at it, claim to have been benefited by their athletic experience. This can mean but one thing, namely, as one of them expresses it, "the increased health and vigor resulting from training more than compensated for any injury due to racing." The exceedingly small number of permanent injuries revealed by this investigation, and the vigorous health enjoyed to-day by the athletes almost without exception, sustain this view especially since it must be borne in mind that a large proportion of the men quit running years ago, before the

highly specialized trainer of to-day was developed, and consequently must have trained under more or less imperfect methods. It should also be remembered that unlike football and crew men, runners are not select specimens of physical manhood, picked because of their strength and vigor. On the contrary, track men are fragile in comparison. Strip a group of football and crew candidates and place them side by side with a group of track men and no one could fail to be impressed by the contrast in strength and development.

Vitality.—Whether distance running drains vitality or not can not be demonstrated in terms of percentage, as one may speak of the number of bodily injuries or of functional heart derangements. A conclusion must be reached deductively, if at all, from the statistics given by the men; the character of the injuries they have received; the nature of the benefits which accrued from their running; the probable effect of these injuries and benefits on their vital organs; the state of their health at the present time, etc. Vitality must be determined by the condition of the blood, and of the organs which maintain life, the heart, lungs, stomach, kidneys, etc. If running has resulted in strengthening the heart and lungs of these athletes, in improving their digestion, in stimulating to greater efficiency the functioning of their vital organs, in endowing them with greater physical vigor, it has evidently given them greater vitality, greater resistance to disease; if, on the other hand, it has injured their hearts, weakened their lungs, injuriously affected their vital organs; if a fair percentage of them have become broken down athletes, it has impaired their physical vigor and drained vitality. Every one admits the value of running *per se.* It is generally recognized as the exercise *par excellence* which develops vital strength, strength of heart and lungs, the kind of strength that carries a man to a green old age. No one of our athletic teams regularly presents to the eye such evidence of perfect physical condition as does the track team. The practical value from a physiological point of view of all the school and college sports is in direct ratio to the amount of running involved. Racing in itself may be injurious, ten per cent. of the men believe it is, although their letters show that half of these are opposed to it, not because of definite and positive injury known to result from it, but from the vague general feeling referred to on the first page of this inquiry, namely, the belief that it is too great a strain. And this investigation shows that certain injuries do result from it, though much less serious than is generally believed. On the other hand, a large majority of the men deny that racing is necessarily injurious, affirming that injury when incurred is caused by poor condition, and that if a man is fit when he toes the mark, he is not likely to injure himself, no matter how hard he runs. But it is impossible to consider racing alone, since running is inseparably connected with it. Boys can not race without training, and will not

train without racing. There seems to be no doubt in the minds of the athletes themselves as to the effects of their running. Over ninety per cent. claim to have derived permanent benefits, in many instances of inestimable value, and only four of the entire number testify to permanent injury. Some of the letters have a direct bearing on the subject of vitality, others relate to it indirectly; one man writes:

> Cornell University is distinguished above all other institutions for the development of runners at the distances you mention. I am in touch with all the 'varsity distance men graduated in the last ten years, and there is not a case of physical debility in the whole lot. Most of them are much more alive than the average man.

A famous distance runner whose feats astonished men a few years ago, writes:

> I have been running for over twenty-three years now, and feel in perfect physical condition. Have won races from seventy-five yards up, and have run over one hundred miles quite often. My heart has been examined by specialists in London, Paris, Boston and other places, and all say that it is in perfect working shape.

Another writes:

> My father, who is sixty-two years of age, and an old distance runner, can now run a quarter mile consistently under sixty seconds. He has not been ill since he was a young man, and is as hale and hearty as a man of thirty.

A quarter mile in sixty seconds is beyond the ability of ninety-nine out of a hundred men whom you and I meet in the streets. The average boy of eighteen years can not do it, but the trained runner can with ease. A form of exercise which develops and maintains in a man sixty-two years of age vigor enough to perform a feat beyond the strength of the average man of half his years and which brings forth testimony such as I have just quoted, has strong claims to favorable consideration.

The Jinrickisha Man.—As bearing upon the general subject of distance running, I have endeavored to ascertain how the jinrickisha men of Japan and the dak or post runners of India have been affected by their arduous occupations. Although the work performed by the jinrickisha man differs widely in character from that demanded by the college athlete training for distance racing, there is a parallel if not similar demand upon the heart and lungs, and the effect should be similar in character, differing only in degree. The jinrickisha man performs infinitely harder work than the college athlete. Twenty, forty and even sixty miles a day is no unusual performance, and while he does not run as fast as the college man, he adds to the burden of his running—which ordinarily is hardly more than a fast jog—the strain of drawing a heavy weight, so that in all probability the cumulative effect upon the vital organs is not only equal to but much beyond that of the college man. In addition to this, he is subjected to all

kinds of temperature—drenched in perspiration one hour, shivering with cold the next, hauling his 'rickshaw in all kinds of weather, inadequately fed, smokes and dissipates. His activities are irregular—he may have work several days in succession, then lie idle for as many more, to be suddenly called upon for a renewed strenuous task—and in general his mode of life is exactly opposite to that of the college athlete, who is required to keep regular hours, fed the most nourishing foods, forbidden tobacco and spirits, is bathed, massaged and runs for fixed periods of time, gradually increasing his performances under the careful eye of an experienced coach. It is extremely difficult to obtain definite information concerning the jinrickisha man. No traveler whose works I have read has been sufficiently interested to publish information of the kind that would be valuable in connection with our inquiry. At the most, but casual reference is made to him as one of the picturesque features of the flowery kingdom. Mr. E. G. Babbitt, American vice consul-general in charge at Yokohama, has been good enough to answer my inquiry, and his letter throws more light upon the subject than I have been able to obtain from any other source. He writes:

> The imperial government publishes annually an elaborate report (statistics) concerning movements of the population, but the number of deaths, etc., are given by "age" and not by "occupation," and it would be a very difficult matter to find the death rate among any particular class. Each prefecture has its own laws and regulations concerning the jinrickisha men and in one of the prefectures the age of the applicants for the jinrickisha's man's license has been limited to fifty-five; in Tokio, this age limit came into force in 1907, at which time it was reported that there were over twelve hundred jinrickisha men over fifty-five years of age. Most of these men were healthy and strong. During the year 1907–1908, this consulate-general had two old janitors, both of whom were jinrickisha men over twenty-five years, they said. The superintendent of police of this district whom I interviewed on this subject attributes a comparatively high death rate among them to their irregular diet and excessive use of liquors, to which vice they appear to be more addicted than any other class of laborers.

Dak and Kahar Runners.—In attempting to investigate the dak or post runner of India, I came into possession, through the courtesy of Mr. G. Lockwood Kipling, of information of especial interest concerning the Kahar caste, also known as Jhinwars in the Punjaub. Mr. Kipling writes that this caste "has for many centuries been village servants, appointed to be carriers, runners, watermen, fishermen, basket makers, water fowl catchers, etc.," and are trained runners from generation to generation. Mr. T. C. Lewis, late director of public instruction, United Province, India, in enclosing to Mr. Kipling the story which follows, writes:

> This goes to show that the Kahars who are in a manner born to the work, and are trained to it from their youth up, can, if they do it regularly (the

oftener the better, as the old man said), cover extraordinary distances and without dropping out of the running at an early age as folks seem to fancy.

Mr. John Harvey, formerly assistant inspector of schools, Lahore Circle, who has had abundant opportunity for observation, writes that these people are not short lived and that they are known to have performed "most extraordinary feats of endurance, such as bearing palanquins and doolies, in carrying bangi loads and in long distance running when laying a palki dak, *i. e.*, arranging for a succession of bearers for an urgent palanquin journey." He says:

I know that Kahars live to be old men, for it is from their own lips that I have heard of feats of long distance running, as sarbarais and proved them to be true. I could give you several instances of incredible endurance.

The following story from Mr. Harvey illustrates the wonderful endurance of the Kahar:

LONG DISTANCE RUNNING (DIALOGUE)

SCENE—Amritsar, N. India. Circ. 1875. Time, 5 P.M.

Dramatis Personæ

J. Harvey	Asst. Inspt. Schools,	Lahore Circle.
Maghi Ram.	Doolie chaudhri,	Amritsar.
Gangu	Son of above.	

J. H. "Ah, chaudhri ji! It is necessary that I should have a doolie to start for Sialkot at 8 this evening."

M. R. "Very good, nourisher of the poor, here is the Order book: please write the order and pay the money Rs 30, at the rate of 4½ annas per bearer for six bearers, 1 sarbarai (forerunner) and 1 misalchi (torchbearer) for each of eleven stages, with Rs 5 for the doolie and the balance for oil."

J. H. "There, count the money—is it all right?"

M. R. "Quite correct, noble presence—Take the Rs 20, and be off with you. The doolie will be here at 7:30, Sahib. Salaam."

J. H. "Stay, chaudhri—That Gangu is your son, I think; now will he go the whole distance to Sialkot (64 miles) before morning, laying my doolie dak and paying the bearers?"

M. R. "O yes, noble presence, why not? That is nothing for a boy of his age (20 years). But *kahars* (doolie-bearer caste) are no longer in condition since the railways came in, though their time was always surer."

J. H. "Nonsense. But it is interesting to know that Gangu will do his 64 miles in 9 hours, if he really does do so. How shall I prove it?"

M. R. "Why, nourisher of the poor, Gangu will pay his respects to you, in duty bound, when you arrive in Sialkot, for he must return to me at once with your assurance that all went well on the journey."

J. H. "Well, I know this is said to be the usual procedure, but is it not a trying piece of work for a young man, especially if he has to do it often?"

M. R. "Great king, the oftener the better; for it is much more trying if undergone only occasionally, though we kahars are in a manner born to the work. Unburdened, we could go on forever, but burdened—well, fifty miles is nothing out of the way for a man in practise. Some of your own bearers will not change for three, four, five or more stages on the way to Sialkot. It will all depend on what men are obtainable on short notice. [This was subsequently verified by J. H. who found one man of his bearers toiling under the doolie into Sialkot who started under it from Amritsar and who proved that

he had the previous day reached Amritsar from Sialkot with a banghy (bamboo shoulder pole with burdens at either end) load of mangoes.] My grandfather was a famous long-distance kahar, and my father, an old man now, still carries his banghy all day."

J. H. "Is it so? But now, listen; how far could your Gangu go without rest on one stretch?"

M. R. "Noble presence, there is no telling how far an unburdened kahar could not go, but Gangu should be able to do one hundred miles without food or rest."

J. H. (cynically) "Ah, indeed! And you, I think, in your day could have done two hundred."

M. R. "Great king, O more than that. Listen, incarnation of justice. Just at the mutiny time, Capt. ——— of Mian Mir sent for doolie chaudhri Tika Ram, and after informing him that he had important despatches for Meerut, asked him if he could arrange for a doolie dak there. I need not tell you the distance, Sahib, three hundred miles as the crow flies—and have him carried with safety. Tika Ram was aghast at the very notion, but when Capt. ——— said he had thought of every other means, and had come to the conclusion that a continuous doolie journey through Patiala and Karnal would be speediest, that not only would the chaudri be well paid, but that the reward would be great if the dispatches could be delivered on the third day, and that if Tika Ram, son of Lalu Ram, could not manage it, no one else could, the chaudhri after considerable thought agreed to undertake it, as it was worth risking. So asking for the bare fare in advance, and stipulating for ten hours start for the sarbarai, he despatched his own son on the business of laying a cross-country doolie dak to Meerut. At the appointed hour, the doolie was at Captain ———'s door and bore him off to arrive without let or hindrance at Meerut on the third day, to be greeted on his arrival by the sarbarai, and to give him assurance that all was well."

J. H. "Enough, enough, chaudhri, that will do. Go."

M. R. "Your noble presence does not believe me. Here is the proof, always carried with me. There, great king, cast your eye over that. What is its purport, O mine of intelligence?"

J. H. (Reading No. 1.) *This to certify* that chaudhri Tika Ram, son of Lalu Ram arranged a doolie dak for me from Mean-Mir to Meerut and that he fulfilled his engagement by having me safely brought with important despatches to my destination.

Signed ————————, *Capt. Mianmir.*

Dated ————————.

No. 2. The bearer of this chaudhri Tika Ram, son of Lalu Ram, has been rewarded with the sum of Rs 1000 for etc., etc.

Signed ————————, *General Commander Mianmir.*

Dated ————————.

No. 3. This is to certify that Maghi Ram, son of Tika Ram, doolie Chaudhri of Mianmir, laid my doolie dak successfully from Mian-Mir to Meerut, etc.

Signed ————————, *Capt. Mianmir.*

Dated ————————.

Looking at the chaudhri—"Humph! I am to believe then that you are the same sarbarai that laid the dak from Mianmir to Meerut which arrived on the third day."

M. R. "Incarnation of justice, your slave is the grandson of Lalu Ram, the son of Tika Ram, and the father of Gangu—Salaam."

Exit.

When one recalls the distances covered in the six-day go-as-you-please contests in vogue in this country some years ago, there is nothing incredible in this. If men of this day can average over a hundred miles a day for six days, what is there incredible in one of a race trained from childhood covering three hundred miles in three days? The interesting fact, in view of the scope of this article, is that the Kahars, trained from childhood to be distance runners, lived to be old men; that they were not only able to stand the strain of running great distances under a heavy load, but thrived under it.

I remember years ago of hearing that the post runners of India died at about the age of forty as a result of their exertions, but I have been unable to find any foundation for such a statement. Positive information in regard to the mortality of Indian post runners is unavailable, as they are relatively very few in number and of inferior caste, so that they are not mentioned as a caste in health statistics. Mr. John Cornwall, late postmaster general in the United Provinces, India, writes, that the Indian mail runners cover fifteen to eighteen miles a day, that there is never any difficulty in getting men to undertake the duties and that he never heard of them succumbing at the early age of forty. The rumor may, he says, have arisen from "the arrangement that Sowcars (bankers or money dealers) and Bunyas (merchants and traders) made in pre-mutiny days, to obtain early information as to the markets, rates of exchange, etc. They employed private persons, trained runners, to outstrip the regular mail carriers and convey information up country from trade centers. It was no uncommon thing, fifty years ago to see these messengers "arriving with messages sealed up in quills, and with their leg sinews swollen and strained from their exertions," but there is no definite and authoritative statement that their lives were shortened by their work.

Conclusions.—It seems to be an open question whether cross-country racing is safe for any but men of exceptional strength with the probabilities in the negative. It is evident that distance racing of any kind is attended with a certain amount of risk, which, however, can be reduced to a minimum by proper training. There is nothing in the testimony given by the athletes to show that distance running depletes vitality. As a matter of fact the presumptive weight of evidence is to the contrary. The facts revealed concerning the jinrickisha men and the Kahar runner emphasize this conclusion. If, notwithstanding his irregular diet, excessive use of liquors, exposure to the elements, etc., the jinrickisha man can live to a reasonable age; if, as shown by Mr. Harvey's testimony, Kahar runners live to be old men notwithstanding their extraordinary feats of endurance, we may safely conclude that the infinitely milder work of the college man, usually done under the best conditions, is not likely to injure him, and the evidence at hand appears to establish this beyond reasonable doubt. But the number of injuries

shown, even though nearly all of them were temporary ones, indicate the need for better supervision. None worthy of the name is given the school-boy athlete, except in comparatively few preparatory schools and city high schools. Competent trainers are scarce, but medical supervision can readily be had. If the boys were required to pass a preliminary examination by a competent physician and were examined thereafter at intervals of three or four weeks to ascertain how they are standing up under the training, liability to injury would be practically eliminated.

Twenty-two of the sixty or seventy colleges and large preparatory schools to which we wrote furnished lists of their athletes. These lists contained the names of two hundred and sixty men, two thirds of whom responded to our letters. The replies are so similar in tone and so emphatic as regards essentials that I believe the results shown will be confirmed by further investigation involving any number of athletes.

THE SYMBOLISM OF DREAMS

By HAVELOCK ELLIS

THE dramatization of subjective elements of the personality, which contributes so largely to render our dreams vivid and interesting, rests on that dissociation, or falling apart of the constituent groups of psychic centers, which is so fundamental a fact of dream-life. That is to say, that the usually coherent elements of our mental life are split up, and some of them—often, it is curious to note, precisely those which are at that very moment the most prominent and poignant—are reconstituted into what seems to us an outside and objective world, of which we are the interested or the merely curious spectators, but in neither case realize that we are ourselves the origin of.

An elementary source of this tendency to objectivation is to be found in the automatic impulse towards symbolism, by which all sorts of feelings experienced by the dreamer become transformed into concrete visible images. When objectivation is thus attained dissociation may be said to be secondary. So far indeed as I am able to dissect the dream-process, the tendency to symbolism seems nearly always to precede the dissociation in consciousness, though it may well be that the dissociation of the mental elements is a necessary subconscious condition for the symbolism.

Sensory symbolism rests on a very fundamental psychic tendency. On the abnormal side we find it in the synesthesias which, since Galton first drew attention to them in 1883 in his "Inquiries into Human Faculty," have become well known and are found among between six to over twelve per cent. of people. Galton investigated chiefly those kinds of synesthesias which he called "number-forms" and "color associations." The number-form is characteristic of those people who almost invariably think of numerals in some more or less constant form of visual imagery, the number instantaneously calling up the picture. In persons who experience color-associations, or colored-hearing, there is a similar instantaneous manifestation of particular colors in connection with particular sounds, the different vowel sounds, for instance, each constantly and persistently evolving a definite tint, as *a* white, *e* vermilion, *i* yellow, etc., no two forms, however, having exactly the same color scheme of sounds. These phenomena are not so very rare and, though they must be regarded as abnormal, they occur in persons who are perfectly healthy and sane.

It will be seen that a synesthesia—which may involve taste, smell

and other senses besides hearing and sight—causes an impression of one sensory order to be automatically and involuntarily linked on to an impression of another totally different order. In other words, we may say that the one impression becomes the *symbol* of the other impression, for a symbol—which is literally a throwing together—means that two things of different orders have become so associated that one of them may be regarded as the sign and representative of the other.

There is, however, another still more natural and fundamental form of symbolism which is entirely normal, and almost, indeed, physiological. This is the tendency by which qualities of one order become symbols of qualities of a totally different order because they instinctively seem to have a similar effect on us. In this way, things in the physical order become symbols of things in the spiritual order. This symbolism penetrates indeed the whole of language; we can not escape from it. The sea is *deep* and so also may thoughts be; ice is *cold* and we say the same of some hearts; sugar is *sweet,* as the lover finds also the presence of the beloved; quinine is *bitter* and so is remorse. Not only our adjectives, but our substantives and our verbs are equally symbolical. To the etymological eye every sentence is full of metaphor, of symbol, of images that, strictly and originally, express sensory impressions of one order, but, as we use them to-day, express impressions of a totally different order. Language is largely the utilization of symbols. This is a well-recognized fact which it is unnecessary to elaborate.[1]

An interesting example of the natural tendency to symbolism, which may be compared to the allied tendency in dreaming, is furnished by another language, the language of music. Music is a representation of the world—the internal or the external world—which, except in so far as it may seek to reproduce the actual sounds of the world, can only be expressive by its symbolism. And the symbolism of music is so pronounced that it is even expressed in the elementary fact of musical pitch. Our minds are so constructed that the bass always seems *deep* to us and the treble *high.* We feel it incongruous to speak of a *high* bass voice or a *deep* soprano. It is difficult to avoid the conclusion that this and the like associations are fundamentally based, that there are, as an acute French philosophic student of music, Dauriac (in an essay "Des Images Suggerées par l'Audition musicale") has expressed it, "sensorial correspondences," as, indeed, Baudelaire had long since divined; that the motor image is that which demands from the listener the minimum of effort; and that music almost constantly evokes motor imagery.[2]

[1] Ferrero, in his "Lois Psychologiques du Symbolisme" (1895), deals broadly with symbolism in human thought and life.

[2] The motor imagery suggested by music is in some persons profuse and apparently capricious, and may be regarded as an anomaly comparable to a synesthesia. Heine was an example of this and he has described in "Florentine

The association between high notes and physical ascent, between low notes and physical descent is certainly in any case very fixed.[3] In Wagner's "Lohengrin," the ascent and descent of the angelic chorus is thus indicated. Even if we go back earlier than the days of Bach the same correspondence is found. In the work of Bach himself—pure and abstract as his music is generally considered—this as well as much other motor imagery may be found, as is now generally recognized by students of Bach, following in the steps of Albert Schweitzer and André Pirro. It is sometimes said that this is "realism" in music. That is a mistake. When the impressions derived from one sense are translated into those of another sense there can be no question of realism. A composer may attempt a realistic representation of thunder, but his representation of lightning can only be symbolical; audible lightning can never be realistic.

Not only is there an instinctive and direct association between sounds and motor imagery, but there is an indirect but equally instinctive association between sounds and visual imagery which, though not itself motor, has motor associations. Thus Bleuler considers it well established that among color-hearers there is a tendency for photisms that are light in color (and belonging, we may say, to the "high" part of the spectrum) to be produced by sounds of high quality, and dark photisms by sounds of low quality; and, in the same way, sharply-defined pains or tactile sensations as well as pointed forms produce light photisms. Similarly, bright lights and pointed forms produce high phonisms, while low phonisms are produced by opposite conditions. Urbantschitisch, again, by examining a large number of people who were not color-hearers found that a high note of a tuning fork seems higher when looking at red, yellow, green or blue, but lower if looking at violet. Thus two sensory qualities that are both symbolic of a third quality are symbolic to each other.

This symbolism, we are justified in believing, is based on fundamental organic tendencies. Piderit, nearly half a century ago, forcibly argued that there is a real relationship of our most spiritual feelings

Nights" the visions aroused by the playing of Paganini, and elsewhere the visions evoked in him by the music of Berlioz. Though I do not myself experience this phenomenon I have found that there is sometimes a tendency for music to arouse ideas of motor imagery; thus some melodies of Handel suggest a giant painting frescoes on a vast wall space. The most elementary motor relationship of music is seen in the tendency of many people to sway portions of their body—to "beat time"—in sympathy with the music. Music is fundamentally an audible dance, and the most primitive music is dance music.

[3] The instinctive nature of this tendency is shown by the fact that it persists even in sleep. Thus Weygandt relates that he once fell asleep in the theater during one of the last scenes of "Cavalleria Rusticana," when the tenor was singing in ever higher and higher tones, and dreamed that in order to reach the notes the performer was climbing up ladders and stairs on the stage.

and ideas to particular bodily movements and facial expressions. In a similar manner, he pointed out that bitter tastes and bitter thoughts tend to produce the same physical expression.[4] He also argued that the character of a man's looks—his *fixed* or *dreamy* eyes, his *lively* or *stiff* movements—correspond to real psychic characters. If this is so we have a physiological, almost anatomical, basis for symbolism. Cleland,[5] again, in an essay "On the Element of Symbolic Correlation in Expression," argued that the key to a great part of expression is the correlation of movements and positions with ideas, so that there are, for instance, a host of associations in the human mind by which "upward" represents the good, the great, and the living, while "downward" represents the evil and the dead. Such associations are so fundamental that they are found even in animals, whose gestures are, as Féré[6] remarked, often metaphorical, so that a cat, for instance, will shake its paw, as if in contact with water, after any disagreeable experiences.

The symbolism that to-day interpenetrates our language, and indeed our life generally, has mostly been inherited by us, with the traditions of civilization, from an antiquity so primitive that we usually fail to interpret it. The rare additions we make to it in our ordinary normal life are for the most part deliberately conscious. But so soon as we fall below, or rise above, that ordinary normal level—to insanity and hallucination, to childhood, to savagery, to folk-lore and legend, to poetry and religion—we are at once plunged into a sea of symbolism.[7] There is even a normal sphere in which symbolism has free scope and that is in the world of dreams.

Oneiromancy, the symbolical interpretation of dreams, more especially as a method of divining the future, is a wide-spread art in early stages of culture. The discerning of dreams is represented in the old testament as a very serious and anxious matter (as in regard to Pharoah's dream of the fat and lean cattle), and, nearer to our time, the dreams of great heroes, especially Charlemagne, are represented as highly important events in the medieval European epics. Little manuals on the interpretation of dreams have always been much valued by the uncultured classes, and among our current popular sayings there are many dicta concerning the significance, or the good or ill luck, of particular kinds of dreams.

Oneiromancy has thus slowly degenerated to folk-lore and superstí-

[4] T. Piderit, "Mimik und Physiognomik," 1867, p. 73.

[5] J. Cleland, "Evolution, Expression and Sensation," 1881.

[6] Féré, "La Physiologie dans les Métaphores," *Revue Philosophique*, October, 1895.

[7] Maeder discusses symbolism in some of these fields in his "Die Symbolik in den Legenden: Märchen, Gebräuchen und Träumen," *Psychiatrisch-Neurologische Wochenschrift*, Nos. 6 and 7, May, 1908.

tion. But at the outset it possessed something of the combined dignities of religion and of science. Not only were the old dream-interpreters careful of the significance and results of individual dreams in order to build up a body of doctrine, but they held that not every dream contained in it a divine message; thus they would not condescend to interpret dreams following on the drinking of wine, for only to the temperate, they declared, do the gods reveal their secrets. The serious and elaborate way in which the interpretation of dreams was dealt with is well seen in the treatise on this subject by Artemidorus of Daldi, a native of Ephesus, and contemporary of Marcus Aurelius. He divided dreams into two classes of *theorematic* dreams, which come literally true, and *allegorical* dreams. The first group may be said to correspond to the modern group of prophetic, proleptic or prodromic dreams, while the second group includes the symbolical dreams which have of recent years again attracted attention. Synesius, who lived in the fourth century and eventually became a Christian bishop without altogether ceasing to be a Greek pagan, wrote a very notable treatise on dreaming in which, with a genuinely Greek alertness of mind, he contrived to rationalize and almost to modernize the ancient doctrine of dream symbolism. He admits that it is in their obscurity that the truth of dreams resides and that we must not expect to find any general rules in regard to dreams; no two people are alike, so that the same dream can not have the same significance for every one, and we have to find out the rules of our own dreams. He had himself (like Galen) often been aided in his writings by his dreams, in this way getting his ideas into order, improving his style, and receiving criticisms of extravagant phrases. Once, too, in the days when he hunted, he invented a trap as a result of a dream. Synesius declares that our attention to divination by dreams is good on moral grounds alone. For he who makes his bed a Delphian tripod will be careful to live a pure and noble life. In that way he will reach an end higher than that he aimed at.[8]

It seems to-day by no means improbable that, amid the absurdities of this popular oneiromancy, there are some items of real significance. Until recent years, however, the absurdities have frightened away the scientific investigator. Almost the only investigator of the psychology of dreaming who ventured to admit a real symbolism in the dream world was Scherner,[9] and his arguments were not usually accepted nor

[8] A translation of Synesius's "Treatise on Dreams" is given by Druon, "Œuvres de Synésius," pp. 347 *et seq.*

[9] K. A. Scherner, "Das Leben des Traumes," 1861. In France Hervey de Saint-Denis, in a remarkable anonymous work which I have not seen ("Les Rêves et les Moyens de les Diriger," p. 356, quoted by Vaschide and Piéron, "Psychologie du Rêve," p. 26), tentatively put forward a symbolic theory of dreams, as a possible rival to the theory that permanent associations are set up as the result of a first chance coincidence. "Do there exist," he asked,

even easy to accept. When we are faced by the question of definite and constant symbols it still remains true that scepticism is often called for. But there can be no manner of doubt that our dreams are full of symbolism.[10]

The conditions of dream-life, indeed, lend themselves with a peculiar facility to the formation of symbolism, that is to say, of images which, while evoked by a definite stimulus, are themselves of a totally different order from that stimulus. The very fact that we *sleep,* that is to say, that the avenues of sense which would normally supply the real image of corresponding order to the stimulus are more or less closed, renders symbolism inevitable.[11] The direct channels being thus largely choked, other allied and parallel associations come into play, and since the control of attention and apperception is diminished, such play is often unimpeded. Symbolism is the natural and inevitable result of these conditions.[12]

It might still be asked why we do not in dreams more often recognize the actual source of the stimuli applied to us. If a dreamer's feet are in contact with something hot, it might seem more natural that he should think of the actual hot-water bottle, rather than of an imaginary Etna, and that, if he hears a singing in his ears, he should argue the presence of the real bird he has often heard rather than a performance of Haydn's "Creation" which he has never heard. Here, however, we have to remember the tendency to magnification in dream imagery, a tendency which rests on the emotionality of dreams. Emotion is nor-

"bizarre analogies of internal sensations in virtue of which certain vibrations of the nerves, certain instinctive movements of our viscera, correspond to sensations apparently quite different? According to this hypothesis experience would bring to light mysterious affinities, the knowledge of which might become a genuine science; . . . and a real key to dreams would not be an unrealizable achievement if we could bring together and compare a sufficient number of observations."

[10] It is interesting to note that hallucinations may also be symbolic. Thus the Psychical Research Society's Committee on Hallucinations recognized a symbolic group and recorded, for instance, the case of a man who, when his child lies dying sees a blue flame in the air and hears a voice say "That's his soul" (*Proceedings Society Psychical Research,* August, 1894, p. 125).

[11] Maeder states that the tendency to symbolism in dreams and similar modes of psychic activity is due to "vague thinking in a condition of diminished attention." This is, however, an inadequate statement and misses the central point.

[12] In the other spheres in which symbolism most tends to appear, the same or allied conditions exist. In hallucinations, which (as Parish and others have shown) tend to occur in hypnagogic or sleep-like states, the conditions are clearly the same. The symbolism of an art, and notably music, is due to the very conditions of the art, which exclude any appeal to other senses. The primitive mind reaches symbolism through a similar condition of things, coming as the result of ignorance and undeveloped powers of apperception. In insanity these powers are morbidly disturbed or destroyed, with the same result.

mally heightened in dreams. Every impression reaches sleeping consciousness through this emotional atmosphere, in an enlarged form, vaguer it may be, but more massive. The sleeping brain is thus not dealing with actual impressions—if we are justified in speaking of the impressions of waking life as "actual"—even when actual impressions are being made upon it, but with transformed impressions. The problem before it is to find an adequate cause, not for the actual impression but for the transformed and enlarged impression. Under these circumstances symbolism is quite inevitable. Even when the nature of an excitation is rightly perceived its quality can not be rightly perceived. The dreamer may be able to perceive that he is being bitten but the massive and profound impression of a bite which reaches his dreaming consciousness would not be adequately accounted for by the supposition of the real mosquito that is the cause of it; the only adequate explanation of the transformed impression received is to be found (as in a dream of my own) in a creature as large as a lobster. This creature is the symbol of the real mosquito.[13] We have the same phenomenon under somewhat similar conditions in the intoxication of chloroform and nitrous oxide.

The obscuration during sleep of the external sensory channels and the checks on false conclusions they furnish is not alone sufficient to explain the symbolism of dreams. The dissociation of thought during sleep, with the diminished attention and apperception involved, is also a factor. The magnification of special isolated sensory impressions in dreaming consciousness is associated with a general bluntness, even an absolute quiescence, of the external sensory mechanism. One part of the organism, and it seems usually a visceral part, is thus apt to magnify its place in consciousness at the expense of the rest. As Vaschide and Piéron say, during sleep "the internal sensations develop at the expense of the peripheral sensations." That is indeed the secret of the immense emotional turmoil of our dreams. Yet it is very rare for these internal sensations to reach the sleeping brain as what they are. They become conscious not as literal messages, but as symbolical transformations. The excited or laboring heart recalls to the brain no memory of itself but some symbolical image of excitement or labor. There

[13] The magnification we experience in dreams is manifested in their emotional aspects and in the emotional transformation of actual sensory stimuli, from without or from within the organism. The size of objects recalled by dreaming memory usually remains unchanged, and if changed it seems to be more usually diminished. "Lilliputian hallucinations," as they are termed by Leroy, who has studied them (*Revue de Psychiatrie*, 1909, No. 8), in which diminutive, and frequently colored, people are observed, may occasionally occur in alcoholic and chloral intoxication, in circular insanity and in various other morbid mental conditions. They are usually agreeable in character, and constitute a micropsia which is supposed to be due to some disturbance in the cortex of the brain.

is association, indeed, but it is association not along the matter-of-fact lines of our ordinary waking civilized life but along much more fundamental and primitive channels, which in waking life we have now abandoned or never knew.

There is another consideration which may be put forward to account for one group of dream-symbolisms. It has been found that certain hysterical subjects of old standing when in the hypnotic state are able to receive mental pictures of their own viscera, even though they may be quite ignorant of any knowledge of the shape of these viscera. This *autoscopy,* as it has been called, has been specially studied by Féré, Comar and Sollier.[14] Hysteria is a condition which is in many respects closely allied to sleep, and if it is to be accepted as a real fact that autoscopy occasionally occurs in the abnormal psychic state of hypnotic sleep in hysterical persons, it is possible to ask whether it may not sometimes occur normally in the allied state of sleep. In the hypnotic state it is known that parts of the organism normally involuntary may become subject to the will; it is not incredible that similarly parts normally insensitive may become sufficiently sensitive to reveal their own shape or condition. We may thus indeed the more easily understand those premonitory dreams in which the dreamer becomes conscious of morbid conditions which are not perceptible to awaking consciousness until they have attained a greater degree of intensity.

The recognition of the transformation in dream life of internal sensations into symbolic motor imagery is ancient. Hippocrates said that to dream, for instance, of springs and wells denoted some disturbance of the bladder. Sometimes the symbolism aroused by visceral processes remains physiological; thus indigestion frequently leads to dreams of eating, as of chewing all sorts of inedible and repulsive substances, and occasionally—it would seem more abnormally—to agreeable dreams of food.

It is due to the genius of Professor Sigmund Freud, of Vienna—to-day the most daring and original psychologist in the field of morbid psychic phenomena—that we owe the long-neglected recognition of the large place of symbolism in dreaming. Scherner had argued in favor of this aspect of dreams, but he was an undistinguished and unreliable psychologist and his arguments failed to be influential. Freud avows himself a partisan of Scherner's theory of dreaming and opponent of all other theories,[15] but his treatment of the matter is incomparably

[14] Sollier, "L'Autoscopie Interne," *Revue Philosophique,* January, 1903. Sollier deals with the objections made to the reality of the phenomenon.

[15] Freud, "Die Traumdentung," p. 66. This work, published in 1900, is the chief and most extensive statement of Freud's views. A shorter statement is embodied in a little volume of the "Grenzfrägen" Series, "Ueber den Traum," 1901. A brief exposition of Freud's position is given by Dr. A. Maeder of Zurich in "Essai d'Interpretation de Quelques Rêves," *Archives de Psychologie,*

more searching and profound. Freud, however, goes far beyond the fundamental—and, as I believe, undeniable—proposition that dream-imagery is largely symbolic. He holds that behind the symbolism of dreams there lies ultimately a *wish;* he believes, moreover, that this wish tends to be really of more or less sexual character, and, further, that it is tinged by elements that go back to the dreamer's infantile days. As Freud views the mechanism of dreams, it is far from exhibiting mere disordered mental activity, but is (much as he has also argued hysteria to be) the outcome of a desire, which is driven back by a kind of inhibition or censure (*i. e.,* that kind of moral check which is still more alert in the waking state) and is seeking new forms of expression. There is first in the dream the process of what Freud calls condensation (Verdichtung), a process which is that fusion of strange elements which must be recognized at the outset of every discussion of dreaming, but Freud maintains that in this fusion all the elements have a point in common, and overlie one another like the pictures in a Galtonian composite photograph. Then there comes the process of displacement or transference(Verschrebung), a process by which the really central and emotional basis of the dream is concealed beneath trifles. Then there is the process of dramatization or transformation into a concrete situation of which the elements have a symbolic value. Thus, as Maeder puts it,[16] summarizing Freud's views, "behind the apparently insignificant events of the day utilized in the dream there is always an important idea or event hidden. We only dream of things that are worth while. What at first sight seems to be a trifle is a gray wall which hides a great palace. The significance of the dream is not so much held in the dream itself as in that substratum of it which has not passed the threshold and which analysis alone can bring to light."

"We only dream of things that are worth while." That is the point at which many of us are no longer able to follow Freud. That dreams of the type studied by Freud do actually occur may be accepted; it may even be considered proved. But to assert that all dreams must be made to fit into this one formula is to make far too large a demand. As regards the presentative element in dreams—the element that is

April, 1907; as also by Ernest Jones, "Freud's Theory of Dreams," *Review of Neurology and Psychiatry,* March, 1910, and *American Journal of Psychology,* April, 1910. For Freud's general psychological doctrine, see Brill's translation of "Freud's Selected Papers on Hysteria," 1909. There have been many serious criticisms of Freud's methods. As an example of such criticism, accompanying an exposition of the methods reference may be made to Max Isserlin's "Die Psychoanalytische Methode Freuds," *Zeitschrift für die Gesamte Neurologie und Psychiatrie,* Bd. I., Heft 1, 1910. A judicious and qualified criticism of Freud's psychotherapeutic methods is given by Löwenfeld, "Zum gegenwärtigen Stande der Psychotherapeutie," *Münchener medizinische Wochenschrift,* Nos. 3 and 4, 1910.

[16] *Loc. cit.,* p. 374.

based on actual sensory stimulation—it is in most cases unreasonable to invoke Freud's formula at all. If when I am asleep the actual song of a bird causes me to dream that I am at a concert, that picture may be regarded as a natural symbol of the actual sensation and it is unreasonable to expect that psycho-analysis could reveal any hidden personal reason why the symbol should take the form of a concert. And, if so, then Freud's formula fails to hold good for phenomena which cover one of the two main divisions of dreams, even on a superficial classification, and perhaps enter into all dreams.

But even if we take dreams of the remaining or representative class —the dreams made up of images not directly dependent on actual sensation—we still have to maintain a cautious attitude. A very large proportion of the dreams in this class seem to be, so far as the personal life is concerned, in no sense "worth while." It would, indeed, be surprising if they were. It seems to be fairly clear that in sleep, as certainly in the hypnagogic state, attention is diminished, and apperceptive power weakened. That alone seems to involve a relaxation of the tension by which we will and desire our personal ends. At the same time by no longer concentrating our psychic activities at the focus of desire it enables indifferent images to enter more easily the field of sleeping consciousness. It might even be argued that the activity of desire when it manifests itself in sleep and follows the course indicated by Freud, corresponds to a special form of sleep in which attention and apperception, though in modified forms, are more active than in ordinary sleep.[17] Such dreams seem to occur with special frequency, or in more definitely marked forms, in the neurotic and especially the hysterical, and if it is true that the hysterical are to some extent asleep even when they are awake, it may also be said that they are to some extent awake even when they are asleep. Freud certainly holds, probably with truth, that there is no fundamental distinction between normal people and psychoneurotic people, and that there is, for instance, as Ferenczi says emphasizing this point, "a streak of hysterical disposition in everybody." Freud has, indeed, made interesting analytic studies of his own dreams, but the great body of material accumulated by him and his school is derived from the dreams of the neurotic. Thus Stekel states that he has analyzed many thousand

[17] This is supported by the fact that in waking revery, or day-dreams, wishes are obviously the motor force in building up visionary structures. Freud attaches great importance to revery, for he considers that it furnishes the key to the comprehension of dreams (*e. g.*, "Sammlung Kleiner Schriften zur Neurosenlehre," 2d series, pp. 138 *et seq.*, 197 *et seq.*). But it must be remembered that day-dreaming is not real dreaming which takes place under altogether different physiological conditions, although it may quite fairly be claimed that day-dreaming represents a state intermediate between ordinary waking consciousness and consciousness during sleep.

dreams, but his lengthy study on the interpretation of dreams deals exclusively with the dreams of the neurotic.[18] Stekel believes, moreover, that from the structure of the dream life conclusions may be drawn not only as to the life and character of the dreamer, but also as to his neurosis, the hysterical person dreaming differently from the obsessed person, and so on. If that is the case we are certainly justified in doubting whether conclusions drawn from the study of the dreams of neurotic people can be safely held to represent the normal dream-life, even though it may be true that there is no definite frontier between them.[19] Whatever may be the case among the neurotic, in ordinary normal sleep the images that drift across the field of consciousness, though they have a logic of their own, seem in a large proportion of cases to be quite explicable without resort to the theory that they stand in vital but concealed relationship to our most intimate self.

Even in waking life, and at normal moments which are not those of revery, it seems possible to trace the appearance in the field of consciousness of images which are evoked neither by any mental or physical circumstance of the moment, or any hidden desire, images that are as disconnected from the immediate claims of desire and even of association as those of dreams seem so largely to be. It sometimes occurs to me—as doubtless it occurs to other people—that at some moment when my thoughts are normally occupied with the work immediately before me, then suddenly appears on the surface of consciousness a totally unrelated picture. A scene arises, vague but usually recognizable, of some city or landscape—Australian, Russian, Spanish, it matters not what—seen casually long years ago, and possibly never thought of since, and possessing no kind of known association either with the matter in hand or with my personal life generally. It comes to the surface of consciousness as softly, as unexpectedly, as disconnectedly, as a minute bubble might arise and break on the surface of an actual stream from ancient organic material silently disintegrating in the depths beneath.[20]

[18] The special characteristics of dreaming in the hysterical were studied, before Freud turned his attention to the question, by Sante de Sanctis, "I Sogni e il Sonno nell' Isterismo," 1896.

[19] See also Havelock Ellis, "Studies in the Psychology of Sex," Vol. I., 3d ed., 1910, "Auto-erotism."

[20] Gissing, the novelist, an acute observer of psychic states, in the most personal of his books, "The Private Papers of Henry Ryecroft," has described this phenomenon: "Every one, I suppose, is subject to a trick of mind which often puzzles me. I am reading or thinking, and at a moment, without any association or suggestion that I can discover, there rises before me the vision of a place I know. Impossible to explain why that particular spot should show itself to my mind's eye; the cerebral impulse is so subtle that no search may trace its origin." Gissing proceeds to say that a thought, a phrase, an odor, a touch, a posture of the body, may possibly have furnished the link of association, but he knows no evidence for this theory.

Every one who has traveled much can not fail to possess, hidden in his psychic depths a practically infinite number of such forgotten pictures, devoid of all personal emotion. It is possible to maintain, as a matter of theory, that when they come up to consciousness, they are evoked by some real though untraceable resemblance which they possess with the psychic or physical state existing when they reappear. But that theory can not be demonstrated. Nor, it may be added, is it more plausible than the simple but equally unprovable theory that such scenes do really come to the surface of consciousness, as the result of some slight spontaneous disintegration in a minute cerebral center and have no more immediately preceding psychic cause than my psychic realization of the emergence of the sun from behind a cloud has any psychic preceding cause.

Similarly, in insanity, Liepmann in his study "Ueber Ideenflucht" has forcibly argued that ordinary logorrhea—the incontinence of ideas linked together by superficial associations of resemblance or contiguity—is a linking *without direction,* that is, corresponding to no interest, either practical or theoretical, of the individual. Or, as Claparède puts it, logorrhea is a trouble in the reaction of *interest* in life. It seems most reasonable to believe that in ordinary sleep the flow of imagery follows, for the most part, the same easy course. That course may to waking consciousness often seem peculiar, but to waking consciousness the conditions of dreaming life are peculiar. Under these conditions, however, we may well believe that the tendency to movement in the direction of least resistance still prevails. And as attention and will are weakened and loosened during sleep, the tense concentration on personal ends must also be relaxed. We become more disinterested. Personal desire tends for the most part rather to fall into the background than to become more prominent. If it were not a period in which desire were ordinarily relaxed sleep would cease to be a period of rest and recuperation.

Sleeping consciousness is a vast world, a world only less vast than that of waking consciousness. It is futile to imagine that a single formula can cover all its manifold varieties and all its degrees of depth. Those who imagine that all dreaming is a symbolism which a single cypher will serve to interpret must not be surprised if, however unjustly, they are thought to resemble those persons who claim to find on every page of Shakespeare a cypher revealing the authorship of Bacon. In the case of Freud's theory of dream interpretation, I hold the cypher to be real, but I believe that it is impossible to regard so narrow and exclusive an interpretation as adequate to explain the whole world of dreams. It would, *a priori,* be incomprehensible that sleeping consciousness should exert so extraordinary a selective power among the variegated elements of waking life, and, experientially, there seems

no adequate ground to suppose that it does exert such selective action. On the contrary, it is, for the most part, supremely impartial in bringing forward and combining all the manifestations, the most trivial as well as the most intimate, of our waking life. There is a symptom of mental disorder called *extrospection* in which the patient fastens his attention so minutely on events that he comes to interpret the most trifling signs and incidents as full of hidden significance, and may so build up a systematized delusion.[21] The investigator of dreams must always bear in mind the risk of falling into morbid extrospection.

Such considerations seem to indicate that it is not true that every dream, every mental image, is "worth while," though at the same time they by no means diminish the validity of special and purposive methods of investigating dream consciousness. Freud and those who are following him have shown, by the expenditure of much patience and skill, that his method of dream-interpretation may in many cases yield coherent results which it is not easy to account for by chance. It is quite possible, however, to recognize Freud's service in vindicating the large places of symbolism in dream, and to welcome the application of his psycho-analytic method to dreams, while yet denying that this is the only method of interpreting dreams. Freud argues that all dreaming is purposive and significant and that we must put aside the belief that dreams are the mere trivial outcome of the dissociated activity of brain centers. It remains true, however, that, while reason plays a larger part in dreams than most people realize—the activity of dissociated brain centers furnishes one of the best keys to the explanation of psychic phenomena during sleep. It would be difficult to believe in any case that in the relaxation of sleep our thoughts are still pursuing a deliberately purposeful direction under the control of our waking impulses. Many facts indicate—though Freud's school may certainly claim that such facts have not been thoroughly interpreted—that, as a matter of fact, this control is often conspicuously lacking. There is, for instance, the well-known fact that our most recent and acute emotional experiences—precisely those which might most ardently formulate themselves in a wish—are rarely mirrored in our dreams, though recent occurrences of more trivial nature, as well as older events of more serious import, easily find place there. That is easily accounted for by the supposition —not quite in a line with a generalized wish-theory—that the exhausted emotions of the day find rest at night.

It must also be said that even when we admit that a strong emotion may symbolically construct an elaborate dream edifice which needs analysis to be interpreted, we narrow the process unduly if we assert that the emotion is necessarily a wish. Desire is certainly very funda-

[21] Extrospection has been specially studied by Vaschide and Vurpas in "La Logique Morbide."

mental in life and very primitive. But there is another equally fundamental and primitive emotion—fear.[22] We may very well expect to find this emotion, as well as desire, subjacent to dream phenomena.[23]

The wish-dream of the kind elaborately investigated by Freud may be accepted as, in what he terms its infantile form, extremely common, and, even in its symbolic forms, a real and not rare phenomenon. But it is impossible to follow Freud when he declares that the wish-dream is the one and only type of dream. The world of psychic life during sleep is, like the waking world, rich and varied; it can not be covered by a single formula. Freud's subtle and searching analytic genius has greatly contributed to enlarge our knowledge of this world of sleep. We may recognize the value of his contribution to the psychology of dreams while refusing to accept a premature and narrow generalization.

[22] On the psychic importance of fears, see G. Stanley Hall, "A Study of Fears," *American Journal of Psychology,* 1897, p. 183. Metchnikoff ("Essais Optimistes," pp. 247 *et seq.*) insists on the mingled fear and strength of the anthropoid apes.

[23] Foucault has pointed this out, and Morton Prince, and Giessler (who admits that the wish-dream is common in children), and Flournoy (who remarks that not only a fear but any emotion can be equally effective), as well as Claparède. The last admits that Freud might regard a fear as a suppressed desire, but it may equally be said that a desire involves, on its reverse side, a fear. Freud has indeed himself pointed out (*e. g., Jahrbuch für Psychoanalytische Forschungen,* Bd. 1, 1909, p. 362) that fears may be instinctively combined with wishes; he regards the association with a wish of an opposing fear as one of the components of some morbid psychic states. But he holds that the wish is the positive and fundamental element: "The unconscious can only wish" ("Das Unbewusste kann nichts als wünschen"), a statement that seems somewhat too metaphysical for the psychologist.

MODERN MEDIEVALISM

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HISTORY moves in a spiral, not in a circle. History does not accommodatingly repeat itself; but it does pass through cycles in which new eras contain social elements and forces which approximate those of periods belonging to earlier cycles. The new is merely the old garbed in more modern attire. The United States is to-day entering upon an epoch in its history which will be marked, in the economic field, by many resemblances to the medieval period. The fundamental economic problems of medievalism clustered around just and fair prices and wages. At present the important and difficult economic problems relate to "reasonable rates," "fair prices" and "living wages." In the twentieth century when these old medieval questions clothed in a strange and youthful garb, appear in an industrial and nominally democratic country and age, the crux of the difficulty is found in the absence of a standard by means of which to measure fair prices, reasonable rates and living wages. The old and rigid status of the feudal régime has disappeared in a large measure under the pressure of the doctrines of free competition and of non-interference. Mobility, rather than fixity, is characteristic of to-day.

The nineteenth century was a unique and transitional era; it constituted the dark ages of economic history. During that eventful period, it was assumed that prices, rates and wages were fixed by the ceaseless action of free and untrameled competition. But, to-day, the existence of numerous rate and arbitration commissions is a concrete and unmistakable warning that free competition does not act at the present moment as our theorists of the past have dogmatically argued that it did. Day by day the competitive field is being gradually narrowed. A strip is securely fenced in on this side; and another portion encroached upon at an entirely different point. At the present moment great and important fields of industrial activity are clearly seen to be outside the competitive sphere. It must, however, be recognized that competition in the halcyon days of the *laissez faire* doctrine was not really free. It was modified and regulated by such legal conventions as private property, inheritance, laws in regard to contract, custom and a variety of other obstructions. The game of economic competition among human beings has always been played according to certain rules. But these rules change. Custom is broken down, on one hand, while monopoly encroaches upon the competitive field, on the other side.

The thinking public correctly recognizes that railway and street railway fares, gas, electric light, water, telephone and telegraph rates are not fixed by a competitive process. Insistent demand is made for fair and reasonable rates in this class of semi-public service. The labor

unionist struggles for fair and living wages. Even the individualistic American farmers are earnestly striving to fix "fair" prices for their wheat, oats, corn, tobacco and other crops. Australia attempts to make the application of a protective tariff to a given establishment dependent upon the payment of "fair" wages to the employees of that concern. A Wisconsin commission is industriously placing a valuation upon the physical property of the public utilities corporations of that state, in order that "reasonable" rates may be promulgated by that official body.

In this manner, the ground is being rapidly cut from under the competitive basis of price regulation. Our commercial edifice still rests on this substructure; but the foundation walls are crumbling, and ominous cracks which presage decay and demolition are appearing in the structure. Society is impregnated with the idea that competition is no longer efficient and sufficient as a guide. From all sections of the country come reports of rate commissions, boards of arbitration, gentlemen's agreements, combinations and legal actions against restraint of trade.

With the narrowing of the competitive sphere the question as to what is a just, accurate and scientific standard of measurement for wages, prices and rates becomes increasingly important; and, at the same time, it becomes more difficult to solve because the basis of competitive rates, prices and wages is being undermined. In fact, if no standard can be found, socialism or anarchy seem to be the only alternatives. Much of the discussion and theorizing as to the respective rights of labor and capital is worthless because either free competition is assumed, or reference is made to prices or wages paid in the past; or some arbitrary standard is postulated which has no reality outside the personal desires of certain individuals or classes.

No court of arbitration or board of conciliation has as yet offered any definite and scientific formula by means of which disputes as to wages or conditions of labor may be adjusted. The findings of that famous board of arbitration, the Anthracite Coal Strike Commission, merely offered a compromise; the commission did not dig down to the roots of the difficulty. Neither did an anxious public receive any exact data or the formulation of any definite method of procedure which might be used as a basis for the work of future boards. A peace was patched up, and the mines were opened. The members of the strike commission honestly and faithfully tried to take into account the physical, social and economic conditions then existing in the anthracite district. They investigated the home and working environment of the miner; his condition was compared with that of other workers. Yet after all, the principal value of this investigation consisted in emphasizing the rights of the general public. The decisions of the Interstate Commerce Commission and of the various state railway and public utilities commissions as to reasonable rates are invariably determined by reference to profits received upon investments in competitive busi-

nesses. An Ohio judge in dissolving a combination of ice dealers ordered the reestablishment of the price charged during the preceding year.

The decision of this judge bears a close resemblance to the action of the English government as to wages immediately after the black death. The present movement toward the regulation of prices, rates and wages is distinctly a reversion to conditions preceding the nineteenth century; and the importance and extent of the movement will necessitate a thorough search for a reliable and scientific standard for the determination of fair wages and fair prices. The medievalists had a very definite conception of fair price; men of to-day are not so favored. During the middle ages these problems were solved by means of the inelastic measuring rod of status, or of class demarkation. Each class in the community had its own rather definite and customary standard of living; and the summit of personal ambition was success within a limited social and economic sphere rather than that of progress from one class to the next higher. Ambition was curbed and chastened by the great fact of birth within a given social compartment. The attempt was made so to regulate prices as to maintain class immobility. With the advent of the era of competition the rigidity of class demarkation was destroyed; and a democratic form of government resting on broad suffrage requirements makes a return improbable. The modern student or statesman instead of resting his theory of fair price upon a basis of special privilege, must place it upon the firm foundation of equality of privileges, upon the abolition of artificial and inherited inequalities. This return to medievalism does not mean a return to artificial and unyielding class demarkations. Society is moving toward a point farther up on the spiral of history. The return to medievalism does mean the elimination of forced and monopoly gains; and is a natural and inevitable product of the progress toward democracy.

If the cornerstone upon which medieval writers based their doctrines regarding fair price has been removed by the increasing power of the non-privileged class; what is left upon which to build a new and democratic doctrine of fair price? In the modern formulation of the doctrine, a fair price for an article or a service is one which will give to the workers who have any useful part in getting the article into the hands of the final consumer, whether that part be in obtaining the raw material, transforming or exchanging these materials, a "fair wage." A fair price will also give to capital a "reasonable rate" of interest, and to the entrepreneur or manager—the man whose genius guides and directs the business—such a return as will keep him in the business and will call forth his best efforts. A fair price does not contain elements which go to make up monopoly profits, or to reward the efforts of unnecessary workers in the complex system of modern industry. This is the basic principle upon which the new economic edifice must be anchored. Competition has led to combination, and combination to

monopoly. A theory of price is needed which preserves the economic value of combination; and, at the same time, removes the evil features of special privileges and of monopoly.

A fair wage is as yet a very elusive and indefinite concept. A fair wage for an unskilled worker would not be a fair wage for the skilled man. The needs of the man are, in the last analysis, the chief factors in determining fair wages. Subjective, rather than objective, considerations have the greatest weight in the eye of modern man. Here is a point of contrast between the modern and the medieval view point. Again, social considerations enter into the problem. How will the man make use of his income? Society desires that a large income go to the man who will make the best use of it—the use which will tend to advance the progress of humanity. A multitude of different opinions will be expressed as to the best uses of income; but certain fundamental conditions are almost universally accepted. Excessive luxury and wasteful consumption in living, in eating, in drinking and the like, are condemned at the bar of society. In general, it is for the good of society that expenditures for luxuries be sent for durable goods rather than upon highly perishable commodities. A fair price for all articles and services would tend to place wealth and income in the hands of those best fitted to handle it; those who would make the best use of it judged from the somewhat theoretical view-point of society as a whole, but not from the standpoint of any special class in the community. A fair wage in an ideal industrial organism would give to each according to his needs; and needs would be proportional to efficiency.

Distribution must now be considered from a non-competitive point of view; and the storm center of discussion will be found in the treatment of rents or monopoly gains. Wages are individual products; but interest and rents must be held to be social, or at least semi-social, products. Social evolution has, it is true, made possible the existing rates of wages; but a sharp line of demarkation may be drawn between wages on the one side, and rent and interest on the other. Individual traits and characteristics play an important part in fixing wages. On the contrary, rents accrue because of social progress, not because of individual efficiency. The man who invests capital is frequently able to gain a personally unearned income, to draw dividends, for example, upon watered stocks. But the man who furnishes his labor receives no extra or special gain. He runs no risk; but in a multitude of cases, the returns accruing to the capitalist or the promoter bear no discernible relation to the risk involved. Individuals are able magically to make capital—paper capital, but of a kind that bears interest. Labor is unable by any sleight-of-hand performance to double or treble its equipment. A dollar may through stock watering, aided by gifts of franchises and rights of way or by special privileges, be apparently changed into two dollars and draw the income of two; but the laborer in the same business can not make it appear that he has four hands or

a dual personality as a worker, and thus double his pay check. In the matter of market opportunity the opportunity is with capital, not with labor. Extra income due to special advantages is capitalized in money, not in labor power.

"Fair" interest and "fair" profits may be manipulated through capitalization of special privileges; but "fair" wages can not be so acted upon. The man stands out in the open. Fair wages are kept down because fair interest and fair profits are so elusive; and because rents are concealed under the guise of interest upon concrete capital, or of profits due to skilful management. If the capital of the country were expressed only in terms of concrete tangible goods, as is proposed by the Wisconsin law, the disproportion between fair wages and fair profits and interest would be evident. The enormous gains of monopoly would then inevitably attract such attention that they would be cut off to some extent at least, and the long distance, impersonal and indirect form of tribute taking would be reduced; although a scientific basis for determining fair wages, interest and profits may not be found.

But there are other tangible bits of evidence which bring to the nostrils of the investigator the musty smell of medievalism. A corporation furnishing a municipality with water which is supposed to be taken from artesian wells, finds it feasible and perhaps cheaper to introduce, into the water mains, without notice to the consumers of the city, polluted water from a river. As a consequence, sickness and death invade many happy homes in the little city. Another company producing a food product uses a deleterious preservative to enable it to foist a partially spoiled article upon an ignorant and unsuspecting public. Sickness, ill-health, reduced efficiency and even death follow unnoticed in the wake of the packages sent broadcast over the land. A railway company neglects to guard its street crossings or to protect its trainmen because of the additional expense connected with such improvements. Again, dead and maimed men, women and children are the direct results of the policy of the heads of the company. This disregard for employees and consumers which is by no means confined to a few isolated cases, is not unlike the nonchalance with which the knight and baron of the middle ages directed the destruction of the homes and the crops of his adversaries and competitors. The toll of the monopolist collected in prices made arbitrarily high is not very different from the toll exacted at the point of the sword by the robber baron.

In the medieval period, a multitude of evils resulted from the interference of the church in secular affairs. To-day political chicanery and corruption are the fruits of the interference of big business interests in legislative affairs. The trust has replaced the church as a dangerous meddler in political affairs. And the alliance between capital and the state is as dangerous, as reactionary and as intolerant as was the medieval alliance of church and state. Economic heresy is now almost as bitterly condemned as was religious heresy in earlier centuries.

THE NATURE OF DISEASE AND OF ITS CURE

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THE earliest explanation of disease, corresponding to the ideas of nature which first impressed the dawning human consciousness, was that the usual working of the body had been upset by the entrance into it of an evil spirit. This spirit proceeded to disturb the "ease" of the body of the sick man, causing it to reject and eject food, racking it with pain, and burning it with the slow fire of fever, and even talking through its lips in incoherent or mysterious utterances. So satisfactory an explanation did this seem that, in modified form, it has a hold with the more superstitious even in the present day.

Such being the cause for his sufferings, the primitive man was prompt to see that the cure should be the driving out of the evil spirit which had taken up its abode in the body, by the most appropriate methods. The medicine man of the tribe assumed a superior knowledge in such affairs and took upon himself the responsibility of dealing with these unseen powers. Working upon the reasonable assumption that what appealed to human senses must also appeal to the dwellers in the spirit realm, that what was agreeable or disagreeable to one must be agreeable or disagreeable to the other, this healer proceeded to make it very unpleasant for the tormentor of the sick man by appearing before him in his most hideous garb, by the repetition of frightful cries and thunderous thumpings upon his tom-tom, while draughts made of the most vile and disgusting substances were poured down the throat of the victim in the hope that the spirit would be induced to let go his hold and depart. It was the most logical treatment imaginable, and it seemed so proved by the fact that the sick man very often recovered. Nor did the primitive mind stop at the mere driving out of the source of disease, but followed up its success in this direction by equally rational attempts at prevention by the wearing of some magic object to keep away the demon of sickness in the future.

As men became more observant and thoughtful, it became apparent that certain physical conditions seemed to have much to do with the presence of sickness. While the spirit realm might be finally responsible for the singling out of the sufferer, yet extremes of heat and cold, dampness, lack of food, and some other agencies were seen to be get-at-able causes. Moreover, it was discovered, more or less accidentally, that the application of heat and cold, bathing, rubbing, and the use of

certain plants often gave comfort and apparently often helped the sick man to recover. So arose the more materialistic cure of disease and the profession of physicians.

By those who studied disease from the more material standpoint many theories were devised to explain the phenomena displayed by the sick. The lack of knowledge of the minute or even the gross structure of the body and its working in health, necessarily made all these attempts at explanation more or less crude and imperfect. Every conceivable "cure" was tried from age to age, and, no matter what the means employed, whether gold or clay, sassafras or tar water, whether the patient was bled or whether sharp hooks were applied to his flesh in order to "draw out the humors," always a certain percentage of patients recovered from the disease and survived the treatment. For the time, at least, the "cure" was apparently justified by the results, and held its place in practise until a change of theories or an unusually long list of failures threw it into disrepute, and it was relegated to the list of things which "have been used but are now found of little value."

The more obvious causes of disease—intemperance, exposure to heat and cold, exhaustion, etc.—were early connected with certain forms of bodily ailments, and even diseases like malaria were known to depend somewhat on local conditions of living, but it is only within recent years that such common affections as pneumonia, tuberculosis, influenza, etc., have been found to have a tangible cause working within the body.

With the discovery of bacteria and their poisons there still remained the questions, What is disease? Why, even in times of plague, are some persons exempt? and why do certain persons recover and others succumb even with the same treatment?

We can no longer look upon sickness as due to the presence within or without us of an evil-natured personality. We must reverse the idea and say that disease is the manifestation of a good consciousness within us, a consciousness which seeks to maintain life by endeavoring to rid the body of a harmful material presence. We realize through abnormal sensations that we are sick—that the body has undergone a change from the condition of health, but within us is a more elemental intelligence of which we are not aware, an older body-mind which, whether we sleep or wake, and even before we are born into consciousness of self, looks after the highly complex and interdependent structures on which life depends, constantly directing its complicated affairs with unerring faithfulness. Disease may be said to be the effort made by the body, directed by this deeper mind, in its attempt to rid itself in most appropriate ways of whatsoever it finds harmful to it, or that threatens its destruction. A fit of vomiting, in which the conscious mind takes a passive and even unwilling part, is but the wise attempt on the part of this inner consciousness to rid the body of that which it finds to be harmful. In the

case of the presence of bacteria, they are at once detected by this bodily consciousness, though the higher consciousness is unaware of their presence. The agencies within the blood, capable of destroying the germs and of neutralizing their poisons, are set to work at high pressure. To the higher consciousness and to the observing mind of another person these efforts become apparent in higher bodily temperature (fever), a more rapid pulse and increased respiration. The bodily machinery is stirred to higher activity, its fires are heightened, and its organs are quickened. Germ-destroying substances are being made in greatest possible amount. The "signs and symptoms" of the disease, or these outward manifestations of internal activity, differ with the kind of germs and with their numbers, the body working more or less characteristically in each case, so that for each germ the "symptoms and signs" are an index to the cause.

Such a disease or body-fight must "run its course," and, no matter what the treatment, that course can at best only be shortened, or the struggle of the body with its enemy made less exhausting by help from without. Where the number of bacteria is large or especially vicious, or where the bodily powers are inadequate for promptly developing its resisting powers, the fight of the body may be of no avail, even with the most skillful aid. On the other hand, if the bacteria are few and the bodily powers are vigorous, the patient will recover even with the most absurd treatment. It is easy to see why the medicine man of primitive society and the miracle workers of a later age often succeeded in "driving out" disease and in effecting apparently marvelous cures.

After once having an infectious disease, such as typhoid, or measles, the body is often exempt from an attack by the same germ. We now know it is not because of special divine favor bestowed upon the individual, but because the body, after passing through one struggle with the bacteria, keeps on hand afterwards a defensive material which quickly destroys any germs of the same kind which find an entrance.

Even in times of epidemics and among those associated with the sick, a certain number of persons always escape without serious signs of the prevailing disease. While the germs no doubt often attack such persons, their protective powers are so perfect that the machinery of the body does not have to be put at work in such a degree as to produce any conscious outward signs of the disease.

For some of these bacterial invasions modern medicine has invented the wonderful expedient of producing, in other animals, similar substances to those which the human body manufactures in its fight against the germs. By inoculating these into the human body the microbes can be prevented from gaining a lodgment, or the body can be greatly aided in its fight against them. Although the body can be thus aided in diphtheria and meningitis, for the attacks of most germs it

must still depend on its own resources in a successful fight against the marauders.

Most of the infectious diseases are of short duration, the body triumphing or failing in its fight in from one to five or six weeks; yet some such fights are long drawn out, and, as in tuberculosis, may cover many years, the disease—the fight—varying in success with the resources of the body and with the amount of drain of bodily energy in other directions. Whether brief or long drawn out, whether acute or chronic, the bodily antagonists often leave scars in the shape of damaged organs—lasting ills which serve to render the body less perfect in its working than before, and also leave their impress on the higher consciousness in feelings of weakness and discomfort.

Besides the bacteria and their poisonous products, other things produce disease more or less insidiously. While the body naturally rids itself through certain organs of the waste matter—the ashes and smoke of its daily activities, continued excesses in eating or drinking throw extra work upon those organs, which in time wear out under added burdens. Exhausting work, excesses of heat or cold, and other unusual conditions also bring about reaction of the inner bodily consciousness to adjust the body to its surroundings. The body makes the best of a bad matter and does its utmost to bring itself into harmony with its outer conditions.

Disease is, then, a life-saving effort of the body, directed by its inner consciousness, in ridding itself of harmful substances within, or of compensating for injured or overworked organs. It is the next best thing to health in that it is nature's way of attempting to bring the body back to that harmonious working of all parts which we call health, and often also of producing protecting substances which prevent future injury from the same source.

While the treatment rendered by the earliest healer, the medicine man, must seem to us absurd, so far as any direct alleviation of suffering is concerned, we can not but guess that the hope which his presence and his, to us, useless efforts inspired in the sufferer, helped not a little to stimulate, through the mind, the failing bodily forces. Mind and body are so intimately related that what affects the one affects the other, and throughout the history of the treatment of disease mental influence has always been used directly or indirectly, consciously or unconsciously, to aid in restoring the body to its state of health.

The higher conscious mind is intimately a part of, or a manifestation of, the body, and is affected by bodily conditions of well or ill being. While it can take little part in directing the defense against foes which have gained an entrance to the body, the mental conditions—the emotions of hope or discouragement—indirectly support or depress the whole of the bodily fighting machinery, for the organ through which

the mind works is closely connected with every other organ of the body and so influences digestion, circulation and all other functions. Likewise the mind is affected by the bodily states. The ill working of damaged organs may produce a mental state of pain or depression. These feelings may be heightened or diminished by mental effort, or may be more or less forgotten, for the time at least, by directing consciousness into some other channel of activity. Disease is, in every case, modified more or less by the mind, and the mental state may sometimes help to determine the success or failure of bodily fight against destructive agencies. If appeal to the mind seems to cure the bodily ill, it does not indicate that the patient would not have recovered anyhow, and does not signify that the mind itself effected the return to health. No amount of faith or other mental state can take the place of insufficient body-resources—can restore a damaged lung or a missing limb.

Disease being thus the attempt of the body to restore itself to its usual condition by ridding itself of destructive agents, the treatment of disease must be directed toward helping the body to this end, by putting the mental and muscular forces at rest, by proper nourishment and by such antitoxins or drugs as aid it in its natural efforts to rid itself of harmful conditions. Better still are the efforts toward prevention of infectious and other injuries by the avoidance of intemperance in eating and drinking, by breathing fresh air, by cleanliness, and by such other means as the body demands to keep it at its best working power. Lastly, the mind should be trained not to meddle too much with bodily affairs, save as it observes the laws of hygiene, and it should be educated to deal readily with the trials and vexations of life in a way that will not affect the general health through depressing emotional discharges.

It will be seen that our modern faith healers make no difference between diseases as regards their cause. In their ignorance, comparable only to that of the primitive medicine man, they deal with all sickness alike. While the condition of the mind has much to do with some diseases, with others it has little or no part in the cure, and the body itself must work out its salvation through that wise inner body-directing intelligence which the higher mind can not know nor—but to a slight extent—influence. The faith curist in the conceit of his ignorance takes the credit for the cures which, through good fortune plus a grain of mental stimulus, often come to pass under his administrations, while he who has studied into the physical nature of disease is perfectly aware that when his patient recovers he has only assisted nature more or less in what she would probably have accomplished without his help though usually not so easily and completely and sometimes not at all. It is this humble knowledge of the limitations of his art that makes the

physician the more anxious, in this age, to prevent disease, for he realizes it is much easier to remove the cause than to help the body in its efforts to throw off the attack. By the purification of drinking water he has greatly reduced the amount of disease from typhoid; by furnishing pure milk the sickness and death of infancy have become much less; by recommending life in pure air tuberculosis is less frequent, etc. Mere faith or mind cure has done and can do nothing of the sort. Medical teaching has also warned against intemperance of all kinds, and against other insidious destroyers of bodily harmony.

The physician has in all ages made use of mental treatment, for, no matter what his remedy in physical form, there has always gone with it a grain of hope. Where he finds the mind especially at fault he may even appeal to it directly, and thus relieve suffering which had its origin chiefly in mental depression or in a too exuberant and untutored imagination. He often succeeds in producing more harmony in bodily working by establishing a happier mental and moral view of life.

As the prevention of the entrance of bacteria or of any other injurious agent into the body is far more economical than the helping to overcome the damages these may produce, so the prevention of unhappy and unhealthy mental states is far better than an attempt to restore a mind to right habits from which it has lapsed.

In primitive times one minister looked after both the spiritual and bodily health of the individual. As the doctor of medicine later assumed the cure of the body, so the doctor of divinity took as his special province the cure of the soul. Mind and body react upon each other, and he who ministers to the one can not but influence the other to some extent. While the priest has abundant opportunity for helping to heal soul-injuries, his larger work, like that of the physician, lies in surrounding those he would help with better social conditions, and in developing, through religious and philosophic training, their individual powers of resistance to the stresses to which the moral nature is daily subjected. For both physical and spiritual ailments prevention is far easier and better than cure.

THE PALEONTOLOGIC RECORD

PALEONTOLOGIC EVIDENCES OF CLIMATE

By T. W. STANTON

U. S. GEOLOGICAL SURVEY

TO every one climate is an interesting theme. The climates of the past, especially when they can be shown to differ in character or distribution from those of the present, attract the attention of the general public, and they are of importance to the special student of geologic history whether his researches deal with the purely physical aspects of the subject or include some branch of paleontologic study.

The evidence as to former climates comes from many sources. The records of deposition and denudation in themselves sometimes give more or less definite indications concerning variations in temperature or moisture or both; the land floras when compared with those now living by their general characters and by the details of their structure, show more or less clearly the climatic conditions under which they lived; the land animals, especially the higher vertebrates, afford a good basis for inferring their habits and hence indirectly their environment, including climate; marine invertebrates give trustworthy evidence of differences in temperature of oceanic littoral waters at least in the later periods. It is obvious, however that the data furnished by any one of these lines of evidence will make only unconnected fragments of the history of past climates and that the evidence on the climate of any particular epoch, if derived from a single source, is seldom so complete or so convincing that corroborative testimony from other sources is not desirable. The subject is one in which general cooperation is essential.

It should be stated at the outset that the most abundant and most definite evidence comes from paleobotany, and will be outlined in Mr. White's paper. The discussion of the data derived from fossil vertebrates must also be left for some one who is qualified to present it, and the whole Paleozoic era may be passed over with the statement that so far as indications from the animal life are concerned the climate of the whole earth was mild and equable. The proof of local exceptions to this statement comes from other sources.

All inferences from paleontologic evidence as to former climatic conditions rest in the final analysis on a comparison with the present distribution of animals and plants with reference to climate. Such comparisons may be general or specific, direct or indirect, and the con-

clusions that may be drawn from them vary greatly in positiveness. To take a familiar example, the reef-building corals are now restricted to shallow waters in which the mean temperature during the coldest month in the year is not less than 68° F., and such conditions are not found in the northern hemisphere north of latitude 32°. Since late Tertiary corals differ but little from those of the present time it is justifiable to assume that coral reefs in late Tertiary rocks indicate waters of about the temperature stated. But when Jurassic coral reefs are found as far north as latitude 53° it is by no means so certain that they indicate a minimum monthly mean temperature of 68° F., and concerning Devonian and Silurian coral reefs in high latitudes the doubt must be still greater. At the present time large reptiles are mainly confined to hot moist climates, but that fact alone can not be considered proof that the Mesozoic dinosaurs required the same kind of a climate.

The impress of climate on the present fauna is shown in various ways. A tropical fauna contains the greatest number of species and exhibits its luxuriance in other ways. Thus, taking shell-bearing marine mollusks to illustrate the general law, Dall has shown in Bulletin 84, U. S. Geological Survey, that the average tropical fauna in shallow waters consists of over 600 species, while the temperate fauna has less than 500 species, and the boreal fauna only 250. Again, there are certain genera that are characteristic of particular zones, and assemblages of forms that are recognized as belonging only to frigid, or temperate, or tropical waters, and in genera that have a wide range many of the species are restricted to certain limits of temperature.

In the late Tertiary faunas which contain a large proportion of living genera and many living species justifiable inferences as to climate may be made from direct comparison with living faunas. By one or another of the tests just indicated, or by a combination of them, Dall has produced convincing evidence that the Oligocene fauna of the Atlantic states was subtropical and that the Oligocene maintains its subtropical character even as far north as Arctic Siberia. He has also shown that the Miocene fauna of Maryland indicates a temperate climate and that a similar cool-water fauna extended at that time as far south as Florida.[1] The fossils of the raised Pliocene beaches at Nome, Alaska, according to the same investigator, furnish evidence of warmer climate during Pliocene time even at that high latitude. By similar methods, in a paper published in the *Journal of Geology,* Vol. XVII., Arnold has recently argued for a series of climatic changes in the late Tertiary and Pleistocene of California.

When the investigation is carried back to the Mesozoic and earlier

[1] See especially Dall's "Contributions to the Tertiary Fauna of Florida," published as Vol. III. of the *Transactions of the Wagner Free Institute of Science,* Philadelphia, and a chapter in the Miocene volume of the Maryland Geological Survey.

faunas in which few of the genera and none of the species are identical with those now living the problem becomes more difficult and the conclusions are much less definite, as the comparisons must be more general. Proofs of actual temperatures as measured in degrees should not be expected unless the botanists can furnish data. There is, however, great local differentiation of faunas and it is fair to ask the question to what extent this is due to differences in climate. One of the earliest discussions of this question was by Ferdinand Roemer, who more than fifty years ago in "Die Kreidebildungen von Texas" noted the fact that the Cretaceous of the highlands in Texas is lithologically and faunally much like the Cretaceous of southern Europe and the Mediterranean region, that it differs from the Cretaceous of New Jersey in about the same way that the southern European Cretaceous differs from that of England and northwestern Germany, and that in each case the European deposit is approximately 10° farther north than its American analogue. He concluded that the differences between the northern and southern facies were due to climate and that the climatic relations between the two sides of the Atlantic were about the same in Cretaceous time as they are now. Roemer's conclusion that there were climatic zones in the Cretaceous may be true, but his reasoning was based on false premises so far as the American deposits are concerned, for the New Jersey type of marine Cretaceous extends with little change all the way from New Jersey to the Rio Grande, and the "Cretaceous of the highlands" with which he contrasted it, now known as the Comanche series, is not represented by marine beds on the Atlantic coast. This shows the necessity for careful stratigraphic and areal work as well as for good paleontology before such broad conclusions can be safely made.

The more general work of Neumayr[2] recognized in the Jurassic and Cretaceous of Europe three faunal provinces designated as boreal, central European, and alpine or equatorial, which on account of their zonal distribution he regarded as indicating climatic differences. He believed that these zones are recognizable throughout the northern hemisphere and cited evidence to show that similar zones exist south of the equator. In recent years Neumayr's conclusions have been questioned by many because in so many instances genera supposed to be characteristic of one zone have been found mingled with those of another. For example, the alpine ammonite genera *Lytoceras* and *Phylloceras* occur in Alaska (lat. 60°) associated with the boreal *Aucella,* and *Aucella* itself ranges from the Arctic Ocean to the torrid zone. Still, in spite of such exceptions and anomalies in distribution, there is much evidence for a real distinction between boreal and southern faunas in the Jurassic and in the Cretaceous which may indicate a zonal distribution of temperature in Mesozoic time. It should be

[2] "Erdgeschichte," Vol. II., p. 330 et seq.

remembered, however, that a boreal climate probably did not then mean a frigid climate, and that the differences in temperature were probably not so great as at the present time.

The conclusions justified by the evidence from fossil invertebrates are:

1. In the Paleozoic there is practically no faunal evidence of climatic zones comparable with those that now exist.

2. In the Mesozoic there is a more or less definite zonal distribution of faunas which may be in part due to differences in climate but this conclusion in each case should be checked by the study of the floras and all other available lines of evidence.

3. From the middle of the Tertiary on through the Pleistocene trustworthy conclusions as to climatic conditions and changes can be made by direct comparisons with the distribution of living faunas.

THE MIGRATION AND SHIFTING OF DEVONIAN FAUNAS

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IN the year 1881 I presented before the American Association for the Advancement of Science the first definite announcement of the theory of recurrent faunas, applying it to the fauna of the Marcellus, Genesee and Ithaca black shales of New York, which I then conceived to be represented by the continuous fauna of the black shales of Ohio, Indiana, Kentucky and Tennessee; and also in the same paper the theory of shifting of faunas was applied to the Hamilton and Chemung faunas of central New York.[1] Since that time a large amount of evidence has been accumulated confirming these hypotheses.

The two hypotheses are correlated. Recurrence, or the departure of a fauna, its replacement by another and its final reappearance in the same section at a higher level, become the facts upon which the hypothesis of shifting of the faunas is based; and only on the assumption of the continuance and shifting of a fauna without losing its characteristics can we satisfactorily explain its recurrence.

The following facts are among the more important which have come to light in the course of my studies:

§ 1. *The Catskill sedimentation* was shown to be thicker and to start lower down in the geological column in eastern New York than in middle and western New York. In eastern New York it began while the Hamilton marine fauna was still present and cut it off, bringing in estuarian conditions with a brackish water and land fauna and flora. In middle New York no Catskill sedimentation is present until after

[1] *Proc. American Association for the Advancement of Science,* Vol. XXX., p. 186, etc.

the arrival of the Chemung fauna; and in western New York no trace of the Catskill type of sediments appears till after the close of the Devonian.

These facts are direct evidence of shifting of the environmental conditions of the edge of the continent westward as the deposits of the middle and upper Devonian were being laid down. With this shifting westward of the off-shore conditions of the sea, there went on a corresponding shifting of several faunas that were adjusted to each phase of those conditions.

These facts were stated in a paper on the classification of the upper Devonian published in 1885.[2]

§ 2. *The Appearance of Dominant Species of a General Fauna in Reversed Order of Succession at the Close of a Fossiliferous Zone.*— The case of *Spirifer lævis* in the Ithaca Zone and of the frequent appearance of *Leiorhynchus* at the opening and close of a fossiliferous zone were among the earliest observed facts suggesting the actual shifting of the body of the fauna entering the area in one order of succession and its departure in the reverse order. In the Ithaca section there occurs at the base of the fossiliferous zone of the Ithaca member a bed containing abundance of *Spirifer* (*Reticularia*) *lævis.* The discovery of the same species at the top of the fossiliferous zone as the normal Ithaca fauna become sparse gave the first suggestion that the faunas were moving or shifting. The Reticularia zone marked the first trace of the fauna to enter and the last to leave the area. Confirmatory evidence was also found in the order of succession of the dominant species of the Ithaca fauna. These facts were reported in 1883.[3]

§ 3. The study of the *mode of occurrence of Leiorhynchus* still further drew attention to the definite order in which series of species came in and went out of any given area. The species of the genus were generally found abundantly at the base or at the top of the fossiliferous zones rich in the brachiopods in the midst of which *Leiorhynchus* was rare.[4]

§ 4. The *reappearance* in a single or few strata of several *representatives of an earlier fauna* long after the formation to which they were normal had ceased.

Slight traces of this fact were observed in the first survey of the Devonian section passing through Ithaca, reported in 1883, Bull. 3, U. S. G. S., and the fauna No. 14 N (p. 15) was called a recurrent Hamilton fauna because of the appearance there of such species as *Spirifer fimbriatus, S. augustus, Pleurotomaria capillaria* and others;

[2] *Proc. American Association for the Advancement of Science,* XXXIV., p. 222.

[3] Bull. 3, U. S. G. S., p. 20, and 1885 *Proc. A. A. A. S.,* Vol. XXXIV., p. 222, etc.

[4] See Bull. 3, U. S. G. S., pp. 16 and 17, 1883.

and higher up in the midst of the Chemung section at Chemung narrows *Tropidoleptus carinatus* and *Cypricardella bellistriata, Phacops bufo* and *Dalmanites calliteles* were found.

The discovery of such traces of an earlier fauna led to further search; and as the evidence accumulated an elaboration and definite formulation of the theory of recurrence of faunas was made which has been set forth in several papers, and is illustrated in detail in the folio of the Watkins Glen-Catatonk quadrangles, which is now in press, for the U. S. Geological Survey (December, 1909).

The facts there brought out are substantially as follows: There are exhibited in the sections mapped for the quadrangles two series of fossiliferous zones; the separate zones of the two series alternate in succession; the zones of one series dominate the western sections of the area and thus thin out or disappear on tracing them eastward; the zones of the second series dominate the eastern sections and particularly the whole eastern New York sections, but thin out westward and in some cases are entirely wanting in sections west of the Watkins Glen quadrangle. The first set of faunal zones includes the faunas of the Genesee shale, the Portage formation and the several divisions of the Chemung formation.

The second set of zones includes the Hamilton fauna proper and recurrent representatives of that fauna which I have named the *Paracyclas lirata* zone, the *Spirifer mesistrialis* zone, the *Leiorhynchus globuliformis* or Kattel Hill zone. These zones are represented by the typical Ithaca group of Hall in its typical sections at Ithaca; and above them appear the first, second and third recurrent Tropidoleptus faunas (which I originally named the Van Etten, the Owego and the Swartwood Tropidoleptus zones, respectively). All of these several fossiliferous zones of the second set become decidedly thin on passing westward across the region. The Ithaca fauna is, occasionally, detected west of the Watkins Glen quadrangle, but is confined to less than 100 feet thickness at Watkins, is recognized for three hundred feet at Ithaca and ranges through at least 600 feet along Tioughnioga River.

Only a slight trace of the Paracyclas zone is seen as far west as Ithaca, but it is well expressed in the section on the east side of the area. The Van Etten, Owego and Swartwood Tropidoleptus zones appear in thin tongues of strata as far west as the Waverly quadrangle and are seen in occasional traces as far west as the Elmira quadrangle. When followed eastward they appear to blend together as a modified Hamilton fauna sparsely appearing in the strata up to the income of the Catskill type of sedimentation.

Where the Hamilton recurrent zones are seen in sharpest expression the recurrent species range through only a foot or a few feet of strata, hold in abundance four or five characteristic Hamilton species such as

Tropidoleptus carinatus, Cypricardella bellistriata, Rhipidomella vanuxemi, Spirifer marcyi and *Delthyris mesacostalis* (= *D. consobrinus*) and others; and the Owego and Swartwood zones appear in the midst of a characteristic Chemung fauna both above and below them. In the Owego recurrent zone both *Phacops rana* and *Dalmanites calliteles* occur.

The Van Etten recurrent zone lies entirely below the range of *Spirifer disjunctus* and associated species of the Chemung formation. On following the sections eastward from the Waverly quadrangle the species of the Chemung fauna become scarce, and east of the Chenango River very few species of the typical Chemung fauna have been detected —although they are still abundant in the Chemung rocks to the southeast and southward across Pennsylvania, Maryland and Virginia.

§ 5. These facts have been interpreted as evidence not only of a general *shifting of faunas* coincident with a rising of the land along the eastern edge of the present continent, but of *oscillation of conditions* and *alternate occupation of the area* by two sets of faunas coming from opposite directions and temporarily living in abundance in the area of central New York.

§ 6. The *lithologic changes* in the sediments containing the different faunas are not sufficient to account for the change in fauna. In quite a number of sections there is no appreciable difference in lithologic constitution between the strata which for a hundred feet thickness have been filled with characteristic Chemung species and the immediately following thin zone (of a foot or two) with scarcely a trace of the Chemung species, but holding, in great number, species which if found by themselves would be undisputed evidence of the Hamilton formation.

§ 7. It becomes necessary therefore to suppose that the *controlling cause* determining the presence of one or other fauna is not the character of the bottom on which the sediments which preserved the fauna were laid. We are thus led to conclude that the qualities of the ocean water have determined the shifting or migration of the faunas. The conditions to which the faunas were adjusted were evidently those of depth, salinity or temperature of the waters in which the species lived; and their change of habitation was occasioned by change in the direction, path or extent of flow of oceanic currents.

This leads us to consider the principles of migration as affecting marine organisms.

§ 8. *Migration of Species and Shifting of Faunas.*—Migration as commonly applied in natural history means the movement of large numbers of the same species from one place to another in a general definite direction at more or less regular periodic times. So birds migrate northward with the advance of warm weather; some fish migrate

from sea up rivers in breeding seasons; pigeons fly eastward or westward in great flocks, or grasshoppers invade a rich country devouring the vegetation in their path, or lemmings migrate across country in great quantities.

The term in these cases has to do with movements of one kind of animal in relation to the comparatively stable range of feeding-ground for the remainder of the fauna inhabiting the areas concerned. The term is rarely if ever applied to the slower movement of the whole body of animals of a fauna, coincident with great changes of climate, such as the advance of the glacial cover over the northern parts of Europe or America produced during the glacial age, or the advance of an Asiatic fauna across the Bering Straits and down the west coast of North America at some Pleistocene time when an ice bridge furnished means of communication by land from one continent to the other. Perhaps there is no impropriety in extending the application of the term migration to these latter cases in which the whole fauna and flora of a region is affected instead of single or a few species; and in which the change of position of habitat is slow and spread over a great period of time instead of being coincident with annual change of seasons. The term may equally well be applied to movements in the seas and movements on the lands.

There is, however, one reason for choosing a separate name for the movements of the latter kind to distinguish them from typical migrations.

In the first class of cases the migration is voluntary and is performed by those organisms which have the power of more or less rapid locomotion. They may be said to do the migrating themselves. In the second case the movements are involuntary and the movement is forced upon all the living organisms of the region and the change in position may be supposed to take place by the contracting on one side of the area of the conditions of possible existence for the species and the extension on the other side of favorable conditions of environment. The movements extend over many generations of life so that relatively sedentary species may gradually adjust their *locus habitans* to a given direction of migration. To this latter process of migration I have been accustomed to apply the term "shifting of faunas."

Migration of species is an expression of the ability of some organisms to appreciate slight changes of favorable conditions of environment and to take advantage of the better conditions during the lifetime of an individual. Shifting of faunas is an expression of the necessity for the perpetuation of the race of certain conditions of environment and the dying out of the whole fauna in the areas from which the favorable conditions are removed with corresponding spread of the fauna into new areas into which the favorable conditions have been shifted.

Shifting of faunas is an expression of the inability of the species of the fauna to survive under the changed conditions of environment which have overwhelmed them in the original habitat; but of an ability on the part of all those which migrate to follow the favorable conditions as they shift from one area to another.

In both typical migration of species and shifting of faunas change in the environmental conditions of life constitute the stimulus to change of habitat on the part of the organisms; and the movement of the organisms is a direct response to the stimulus—those organisms in the first case which migrate showing their greater vitality compared with their neighbors who stay at home; while those who stay at home show a greater power of endurance and organic adjustment to wider range of environmental conditions.

In the case of the shifting faunas those which endure without change of characters exhibit an acquired closeness of adjustment to some particular combination of environmental conditions which they are forced to follow or die and suffer annihilation. The evidence of their endurance is indicated by return and reoccupation of the same area at a later geological stage when by their reappearance, the original condition of environment may be assumed to have recurred.

In the case of living organisms evidence of migration is found in the actual presence of the species at one time in a region at a considerable distance from its ordinary *locus habitans;* and in some cases by seeing the species in the process of migration, as for instance the temporary alighting in fatigued condition of flocks of northern land birds on Bermuda Island on their migration southward.

In the case of fossil species the shifting of a fauna is expressed by the presence of a number of species representing an earlier fauna in a stratum in the midst of rocks containing a different and dominantly later set of species.

The fauna is then said to recur and it is the recurrence of the fauna which forms the basis for the inference that the fauna has shifted its *locus habitans* during the period of time represented by the sedimentary deposits separating the formation in which the fauna is dominant from the zone in the higher formation in which the recurrent species are found.

This theory of the shifting of place and the recurrence in time of the same fauna involves certain conceptions as to the nature of species and the laws of evolution which it is important to consider.

§ 9. *Evidence of Continuity.*—To establish evidence of motion in migration as in any other kind of motion it is all important to know that the body or bodies to which the motion is ascribed is continuously the same.

In the Devonian case I have been studying the moving body is a

fauna; not only have I found it necessary to establish identity of the species in the recurrent zones with those of the initial zones, but it is essential to show that the faunas as a whole are the same.

To put this in another form of statement we must establish the fact that not only the individual species have retained their specific characters, but the further fact that the equilibrium of adjustment to each other in the faunal community has not been changed, in order to prove that the recurrent fauna is the direct successor of a fauna represented in the rocks at a lower horizon.

This has led to such distinction as rare and dominant species of the fauna, and only as some such comparative frequency of the species in the faunal combination is apparent can we be sure that we are not considering an accidentally accumulated sample of a general fauna.

The presence of occasional associated species belonging to the normal fauna of the formation in which the recurrent zone appears is not antagonistic to the theory, because the theory proposes an invading of the territory occupied by the normal fauna, and whatever were the causes which brought about the shifting of the fauna they were not so completely different as to annihilate all evidence of the fauna previously occupying the ground. Hence it is only necessary to find an abrupt change of the grand majority of species to make the induction that the faunas have shifted their habitat.

The theory involves the further conception of grand general faunas which have their center of habitat and distribution in permanent oceanic basins, as distinguished from the special and (in geological strata) temporarily expressed faunas such as we are accustomed to associate with individual geologic formations.

In the case before us two such general faunas are in evidence, one of which in its dominant characteristics is traced westward into Iowa, Idaho and Arizona and up the Mackenzie River valley to the north and across the polar regions to Russia and northern Europe. The other is traced eastward and southward into central and southern Europe and also dominantly into South America.

Although, with our present knowledge, it is not possible to determine in any temporary expression of marine faunas those particular species which were derived from one from those derived from the other grand source, it is possible to recognize numerous species which belong to one center of distribution and others that belong normally to the other.

§10. *Interpretation of the Facts.*—It is also important to keep our heads clear in interpreting the facts.

It is only by close examination and comparison of the fossils themselves that identity of species or identity of faunas can be established.

The fixed characters of species are not only the characters by which

one species is distinguished from another, but they are of generic, ordinal and even class value, and they may be of immense age in the race and mark no special, narrow stage of its history.

It is a question of interpretation whether each particular phase of expression of fluctuating characters is a matter of time or of environment.

I have reached the conclusion that it is those species which have the greater degree of normal and persistent fluctuation of character which migrate and follow the shifting conditions of environment, and their life period is correspondingly longer.

On the other hand species whose plasticity of characters is narrow, are more closely adjusted to their environment, are local in their range of habitat, and temporary in their geological life-period.

Interpreting the facts on this basis it is the phases of continuously fluctuating characters in species of wide geographic distribution and long geologic range which furnish the most satisfactory evidence of temporary stages in the life history of faunas.

Another question of interpretation arises when we attempt to reconstruct the physical condition of the environment at successive stages of time.

In a single vertical section we have positive evidence of succession in time. If we were sure that no recurrence of the same fauna could take place we could correlate two vertical sections strictly upon the fauna contained in the strata, on the basis of the supposition that the single fauna appeared but once in the section and that when it ceased in a given section its whole life period was expressed. But the facts show us that this is not the case in nature. In geological times as in the present, we know that many distinct faunas are living on the face of the earth at the same time, even for very similar conditions of environment. It becomes therefore a very complex matter to correlate two sections in which the order of faunas and the character of the sediments differ; which is generally the case for any two sections separated by fifty miles from each other, although on stratigraphic evidence they may be properly interpreted as covering the same interval of time.

PALEONTOLOGIC EVIDENCES OF ADAPTIVE RADIATION

By Professor HENRY FAIRFIELD OSBORN
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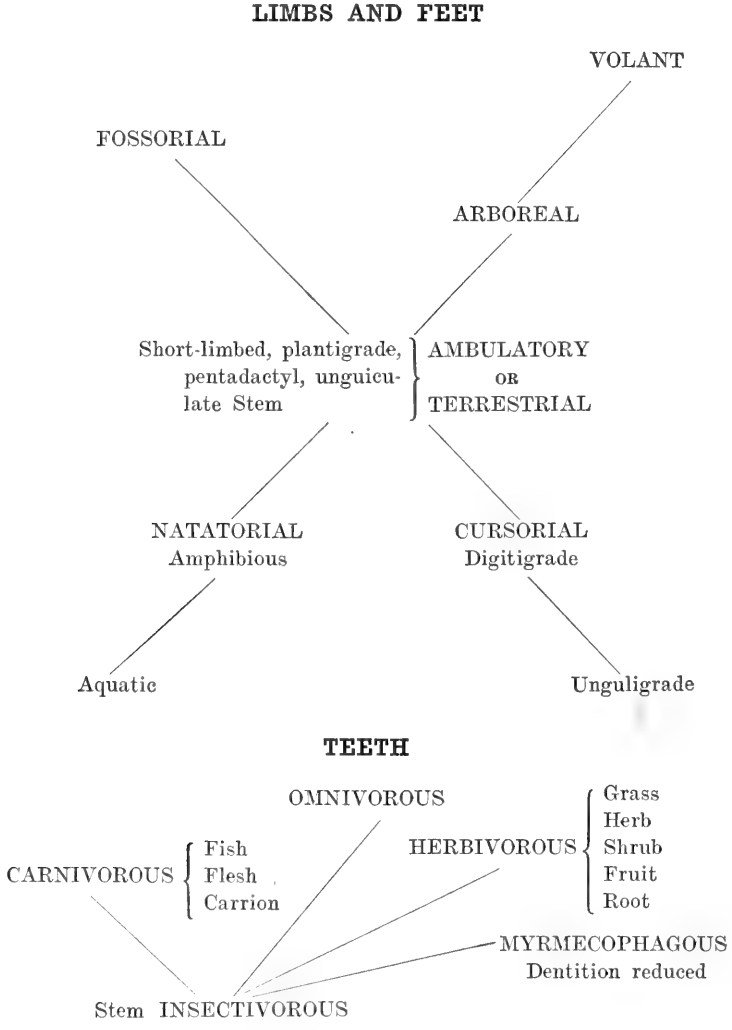
THE law of adaptive radiation[1] is an application of paleontology of the idea of divergent evolution as conceived and developed successively in the studies of Lamarck, Darwin, Huxley and Cope. It

[1] Osborn, H. F., "The Law of Adaptive Radiation," *Amer. Naturalist*, Vol. XXXVI., No. 425, pp. 353–363.

is more than divergence because it implies evolution in every direction from a central form. The idea of radii, or radiations from a central form greatly assists the imagination, because a distinctive feature of paleontology is that we are constantly dealing with fragments of history. The radiations which have been discovered must be supplemented by those which remain to be discovered, and it is very remarkable how in group after group of animals these missing "radii" have turned up.

Radiation actually begins in certain single organs, and the first principle to be observed, as shown in the accompanying diagram, is



Main Lines of Adaptive Radiation of (*a*) limbs and feet, (*b*) teeth among mammals.

that radiation of different parts of the body is not necessarily correlated; that is, that the adaptive divergence of the feet and limbs may take one direction, while that of the teeth and skull may take another direction. Thus great variety in combinations of characters may arise, bringing about the very antithesis of Cuvier's supposed "law of correlation"; for we find that while the end results of adaptation are such that all parts of an animal conspire to make the whole adaptive, there is no fixed correlation either in the form or rate of development of parts, and that it is, therefore, impossible for the paleontologist to predict the anatomy of an unknown animal from one of its parts only, unless the animal happen to belong to a type generally familiar. For example, among the land vertebrates the feet, which are associated with the structure of the limbs and trunk, may take one of many lines of adaptation to different media or habitats, either aquatic, terrestrial, arboreal or aerial; while the teeth, which are associated with the structure of the skull and jaws, also may take one of many lines of adaptation to different kinds of food or modes of feeding, whether herbivorous, insectivorous or carnivorous. Through this independent adaptation of different parts of animals to their specific ends there have arisen among vertebrates almost unlimited numbers of combinations of food and tooth structure.

Alternations of Habitat.—In the long vicissitudes of time and procession of continental changes animals have been subjected to alternations of habitat either through their own migrations or through the "migration of the environment itself," to employ Van den Broeck's epigrammatic description of the profound and sometimes sudden environmental changes which may take place in a single locality. The traces of alternations of anatomical adaptation corresponding with these alternations of habitat are recorded both in paleontology and anatomy. For example, Huxley in 1880 briefly suggested the arboreal origin of all the marsupials, a suggestion which has been confirmed abundantly by the detailed studies of Dollo and Bensley, according to which we may imagine that the marsupials have passed through a series of phases, as follows: (1) a very early "terrestrial or ambulatory" phase, (2) a "primary arboreal" phase as exemplified by the tree phalangers of the present day, (3) a "secondary terrestrial" phase as exemplified by the kangaroos and wallabies, (4) a "secondary arboreal" phase as exemplified by the tree kangaroos.

Each one of these phases has left its anatomical record in the structure of the feet and limbs, although this record is often obscured by adaptation.

Louis Dollo especially has contributed most brilliant discussions of this theory of "alternations of habitat" as applied not only to the interpretation of the anatomy of the marsupials but of many kinds of

fishes, and to such reptiles as the herbivorous dinosaurs of the Upper Cretaceous.

This brief consideration of the external features of adaptation leads us to glance at groups of animals. We here observe the influence of geographic distribution; we observe the *adaptive radiation of groups both continental and local.*

Continental Adaptive Radiation.—Among the Tertiary mammals we can actually trace the giving off of radii in several, sometimes in all, directions for the purpose of taking advantage of every opportunity to secure food, to escape enemies, and to reproduce kind, the three phenomena of the struggle for existence. Among such well-known quadrupeds as the horses, rhinoceroses and titanotheres the modifications involved in these radiations can be clearly traced. Thus the history of the life of continents presents a picture of contemporaneous radiations in different parts of the world. We observe the contemporaneous and largely independent radiations of the hoofed animals in South America, in Africa and in the great continent comprising Europe, Asia and North America.

Through the laws of parallelism and convergence each of these radiations produced a greater or less number of analogous groups.

While originally independent, the animals thus evolved separately as autochthonous types in many cases finally mingled together as migrant or invading types.

We may thus work out gradually the separate contributions of the great land masses of North America, South America, etc., to the mammalian fauna of the world. As a rule the greater the continents the more important and fundamental the orders or larger groups of mammals which have radiated in them; the lesser land masses and continental islands, like Australia, have been less favorable to wide adaptive radiation. One of the most interesting features of adaptive radiation is that it may also occur locally.

Local Adaptive Radiation.—On a smaller scale are the local adaptive radiations which occur through segregation of habit and local isolation in the same general geographic region wherever physiographic and climatic differences are sufficiently great to produce local differences in food supply or other local factors of change. This principle is well known among living animals, and it is now being demonstrated among many of the Tertiary mammals, remains of four or five distinct genetic series having been discovered in the same geologic deposits.

The existence of multiple phyla of related animals, as of the rhinoceroses, horses and titanotheres in the same localities is due partly to the operation of the law of local adaptive radiation.

This is conspicuously the case among the titanotheres, for example, the chief evolution of which can be traced in the Rocky Mountain

region. In the Eocene we discover four or five independent local phyla; again in the Oligocene we discover five or six independent local phyla. The evolution of these animals appears to have been chiefly American.

In other cases, however, the polyphyletic condition appears to have been through the mingling with local phyla of phyla evolved in other countries. This is illustrated in the case of the Middle Miocene rhinoceroses of America, which are invaded by rhinoceroses of Eurasiatic or European origin.

In studying the herbivorous quadrupeds, therefore, we must keep in the imagination constantly the production of local phyla through local radiation and the intermingling of foreign phyla through migration. There are a few very striking and profound differences between quadrupeds which recur so frequently that where we discover one form we may surely anticipate the discovery of the opposite or antithetic form: in other words, there are extremes of structure shown in the proportions of the skull, of the teeth, of the limbs, and groups of quadrupeds are constantly tending through adaptive radiation to reach these extremes. Some of the contrasting extremes are the following: brachyodonty *vs.* hypsodonty, dolichocephaly *vs.* brachycephaly, dolichopody *vs.* brachypody.

For example, a local adaptive radiation observed in the horses is that the forest-living types are brachyodont, or possess short-crowned teeth, while the desert-living horses are hypsodont, typically grazers, with long-crowned teeth.

Extremes of long-headedness and short-headedness, of long-footedness and of short-footedness, comprise a very large part of the mechanism of adaptive radiation; but we have to do also with long-necked and short-necked types, and with many other chances of proportion which are correlated with different feeding habits.

INSTINCT AND INTELLIGENCE IN BIRDS—II

By Professor FRANCIS H. HERRICK
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THE cyclical instincts of birds, present, as we have seen, a well-ordered series, rising and waning in due course, until the reproductive cycle is complete. Nevertheless, the order and harmony which commonly prevail are subject to many disturbances of a transient, or of a more lasting character. When variations in the cycle, whatever their nature, become regular and permanent, any consequent loss or injuiry to the species seems to be counterbalanced by the rise of new instincts in both young and adult, which may involve marked structural changes, as shown in the parasitic cuckoos of the old world and their non-parasitic relatives of the new. If transient merely, there is more or less individual loss, according to the nature and extent of the disturbance.

We shall now consider some of these variations in the cyclical series, and we may assume, though with little exact knowledge, that when any character of the sort to be described has become general or permanent this has been effected through a gradual process of selection, with or without environmental influence and other unknown agencies. We may further assume that all modern birds originally built proper nests, and there can be little doubt that many either falter or fail in this work at present through the loss of an instinct which they once possessed; but this question aside, we can be reasonably assured that all originally concealed or guarded their eggs.

The nest, in the first instance, tends to secure a more equable distribution of warmth and moisture for eggs or young; incidentally it may conceal and therefore protect both young and adult, and add to the comfort of the whole family. There would seem to be a vast difference between digging a hole in the warm, moist sand, as we see the turtle, or the moleo, one of the brush turkeys, doing, and weaving through the unremitted efforts of many days, a beautiful pouch like the oriole's, so admirably adapted for protection, both by its form and by its position. Yet it is by no means certain that the fundamental nest-building instinct is entirely wanting in the moleo, the peculiar habits of which will be later considered.

Nest-building of one kind or another is found in all classes of vertebrates, and the guarding and fighting instincts at nesting-time are as strong in some of the fishes as in birds, but while the practise is

clearly of ancient origin, it is by no means universal; it seems in every case to be related to the needs of the animal, and to be a refinement of more simple means of securing both concealment and protection.

The causes of the disturbances, which we have to describe, are wholly obscure. We can only surmise that they may have their origin in changes in the central nervous system, which, as one result, bring about disturbances in nutrition, leading now to a premature, now to a belated development of the reproductive cells. At all events there arises what may be crudely described as an "overlap" or "blending" of instincts. Or, we may say that in the struggle of conflicting impulses victory now goes to one side, now to the other. The only facts that are really known are that the egg sometimes anticipates the nest, instead of the nest the egg, or that the migratory impulse may emerge too soon, and nip the proper parental instincts in the bud, before they have run their course. We do not doubt that the sifting process of selection would soon curb any tendency, like the last, in every species which was destined to survive.

The eccentricities of behavior, which we attribute to disturbances in the breeding cycle, will be examined under the following heads: (1) Beginning a new cycle, and scamping an old; (2) multiple and superimposed nests; (3) eccentric behavior due to conflicting instincts; and (4) premature laying of eggs, omission of nest-building and parasitism.

II. Beginning a New Cycle or Scamping the Old

When the cyclical instincts rise and wane in their proper order, they may be represented by a series of circles tangent to each other, or with but little overlap (Fig. 15). Beginning at term 3 or 4, a cycle[1] is

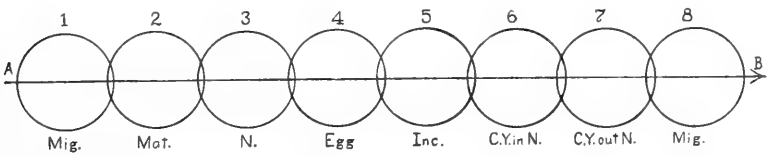


Fig. 15. Diagram to illustrate the serial instincts of the Reproductive Cycle, with types of activities expressed in eight terms.

completed up to term 7 for each brood successively reared. Most wild birds in this part of the world have but a single brood in the season. The success of any individual pair depends upon circumstances. Storms and predaceous animals of all kinds break down the nests or destroy the eggs, when a fresh start is usually taken.

In very timid birds like the cedar waxwing, the cycle is often

[1] That is, when it is limited to the direct reproductive activities, the relation of which to migration is not important in this discussion.

abruptly ended at term 3 or 4, as a result of fear, through discovery or disturbance of the nest, and a new series is promptly begun at 3. This is the simplest type of disturbance which we can record (Fig. 16).

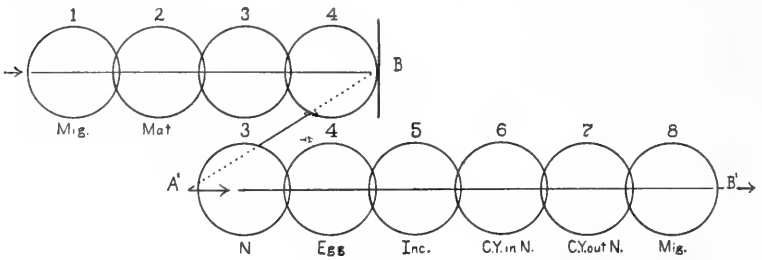


FIG. 16. DIAGRAM OF ANY GIVEN REPRODUCTIVE CYCLE—*A–B*, interrupted by fear or accident at term 4, and a new cycle, A^1B^1, begun at term 3.

The old nest may be torn down by the little builders, and its materials used again, but this does not commonly happen. Since fear is rapidly depressed, with the rise of the brooding instinct, beginning at term 5, interruptions are less liable to occur after this point is reached, but wherever the thread is dropped, it is usually picked up again at stage 3.

Of far greater interest is the fact that a new cycle may be begun at the very close of the breeding season, when it seldom goes far, and is bound to fail for lack of time. Probably no stronger witness to the instinctive basis of the behavior of birds could be found than this recrudescence of the reproductive activities at a time when most must answer the fatal summons of the migratory impulse. It is typically illustrated by the great herring gulls, which toward the close of their usual cycle in mid-July begin to build new nests, and will even lay eggs in them, though all are eventually abandoned. It would not be surprising to find that many young were also left to their fate, but my observations have never extended late enough to determine this definitely. At the Great Duck Islands, Maine, where these facts were gathered, the birds arrive early in March, and depart about September 1, according to the warden and lighthouse keeper, Captain Stanley, who has found that the first eggs are laid about the middle of May, while the first young begin to appear the second week in June.

In a census of one hundred nests of this gull taken on the island July 17, 1902, at the close of the breeding season, some interesting facts were brought out, which may be summarized as follows:

Abandoned empty nests, from which young have been reared	64
Abandoned nests with addled eggs	8
Nests with chicks outside	5
Nests with newly hatched chicks or pipped eggs	1
Nests with fresh or slightly incubated eggs	5
New nests, begun or completed	17
Total	100

FIG. 17. IMPERFECT NEST OF GREAT HERRING GULL, illustrating the beginning of a new breeding cycle, when too late to be finished. Chips, grass, and roots have been brought to the new site. Great Duck Island, Maine, July 20.

Of the seventy-seven nests which had seen service in the season, eight only contained addled eggs. It was certain that none of the new nests, with or without eggs, could ever come to anything, and probably most were never finished. They are made to be abandoned, sooner or later, with the rise of stronger instincts. A new cycle is begun, but

FIG. 18. NEST OF GULL, illustrating the same tendency as that shown in Fig. 17, but where the old nest was "repaired," or used as a site for the new one. The body of a dead chick was worked into this nest, and the old bird was incubating an addled egg. July 22.

FIG. 19. GULL'S NEST ON ROTTEN LOG, with eggs starred and nearly ready to hatch, probably belonging to a bird which had earlier failed, but had renewed its activities in time to sucessfully rear young. July 20.

stayed at terms 3 or 4. Now it might be supposed that those nests which appear in middle or late July (Figs. 17–18) were the work of young birds, or of others which for some cause had not met with earlier success, but this is certainly not always the case. For the space of several days I watched a pair of gulls, which had large chicks to feed, and repeatedly saw them leave their young and begin the construction of a new nest about a rod from the old one. The female would split

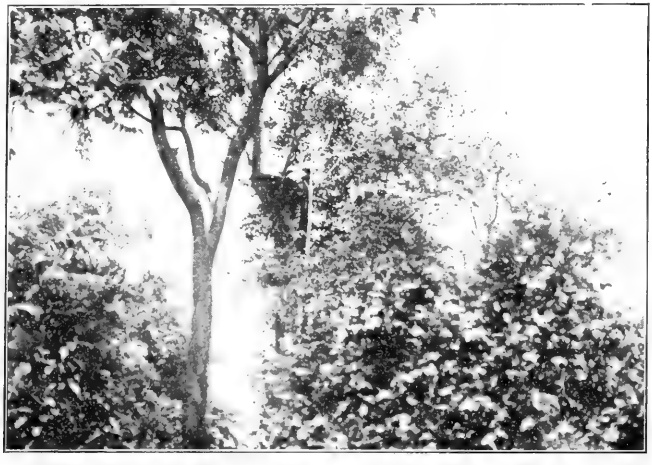


FIG. 20. WHITE-HEADED EAGLE'S NEST OF THE FIRST YEAR, built in 1900, by the owners of the ærie shown in Fig. 21, which was destroyed the previous winter. The nest is considerably broader than tall.

chips, carry them to the chosen site, and go through the instinctive moulding and turning movements in the most approved and characteristic manner. The male even mounted the female, and was borne on her back like a circus-rider, in his evident attempt to perform an act

FIG. 21. ÆRIE OF EAGLE OCCUPIED FIFTEEN YEARS, and nearly twice as tall as broad; the predecessor of the nest shown in Fig. 20 In dead sycamore, three and one half feet in diameter at base; top of nest 77 feet from ground.

which is usually necessary. In this case, however, eggs were not destined to appear, and the new nest was eventually given up. This sporadic attempt at nest-building, while there are still chicks to be nursed, illustrates what we have described as the conflict of opposing instincts.

At the beginning of the breeding season in the gull, old nests are frequently reclaimed, and possibly by the same birds, though this has not been determined, or a new site is chosen, and a new nest built. If an addled egg is left after the others have hatched, "repairs" to the nest are frequently undertaken, and the old egg is either incubated for several days longer or it is buried out of sight. A pair of gulls, which was watched from the tent, had a single chick, and this one

lived only long enough to crawl out of its shell, while a second egg was bad. No sooner was the little one dead, than the work of reconstruction, that is building on the old site was begun, and the body of the chick, treated as so much nesting material, was soon buried under new layers of grass and chips (Fig. 18). This labor lasted for four days, or as long as I was able to watch it, but as in the other cases described, it was sure to be futile owing to the lateness of the season.

Fish hawks and eagles are known to return to their old nests year after year, adding fresh materials, that is, building on the old site, each season. An eagle's nest of the first year (compare Figs. 20 and 21) is broader than tall, but with the yearly increment of stubble and sticks added to its top, it gradually rises in vertical height, until becoming so much taller than broad, in certain situations it tends to topple over from sheer weight. The older of the two nests of the white-headed eagle, which are here shown (Fig. 21), was begun in the crotch of a dead sycamore, 77 feet from the ground at North Springfield, Ohio, in 1885, and occupied for fifteen years, or until January, 1900, when this ancient landmark was laid low in a storm. With the aid of photographs, taken in May, 1899,[2] and by actual measurements which I later made on the prostrate tree, the dimensions of this great nest were exactly determined. It was nine feet high and six feet in diameter, or three feet taller than broad, and contained rather more than three cubic yards of wood, earth and stubble. The new nest (Fig. 20), which was built in the spring of 1900, was examined and photographed in June of the same year; now after the lapse of a decade, it has much the appearance of the older nest, having risen greatly in height. Such a structure might be regarded as a kind of "multiple nest," being composed of increments, corresponding in number to the years of occupation, the last "nest" being built on the *site* of that of the previous year.

But a more interesting fact, if true, is the statement of Audubon[3] and others that ospreys and eagles often repair their nests in the autumn, as if in anticipation of the needs of the coming year. We can readily accept the fact, but not the interpretation, for if such a practise really occurs, it is plainly due to the rise of a new reproductive cycle, which is begun but soon checked. The sporadic return of the nest-building instinct at the close of the season is essentially the same in hawk or gull, and can imply no more intelligent forethought in one case than in the other.

[2] By Mr. H. E. Denio, of Milesgrove, Pa., to whose kindness I am indebted for their present as well as a former use.

[3] Audubon speaks only of the fish hawks, which he says but seldom alight on the ground, as "when they collect materials for the purpose of repairing their nest at the approach of autumn." "Ornithological Biography," Vol. I., p. 419, Edinburgh, 1831.

Desertion of the Young under the Impulse of Migration

The struggle of conflicting instincts is clearly shown when the normal cycle is brought prematurely to a close by the rise of the instinct of migration, when eggs or young are left in the nest to perish.

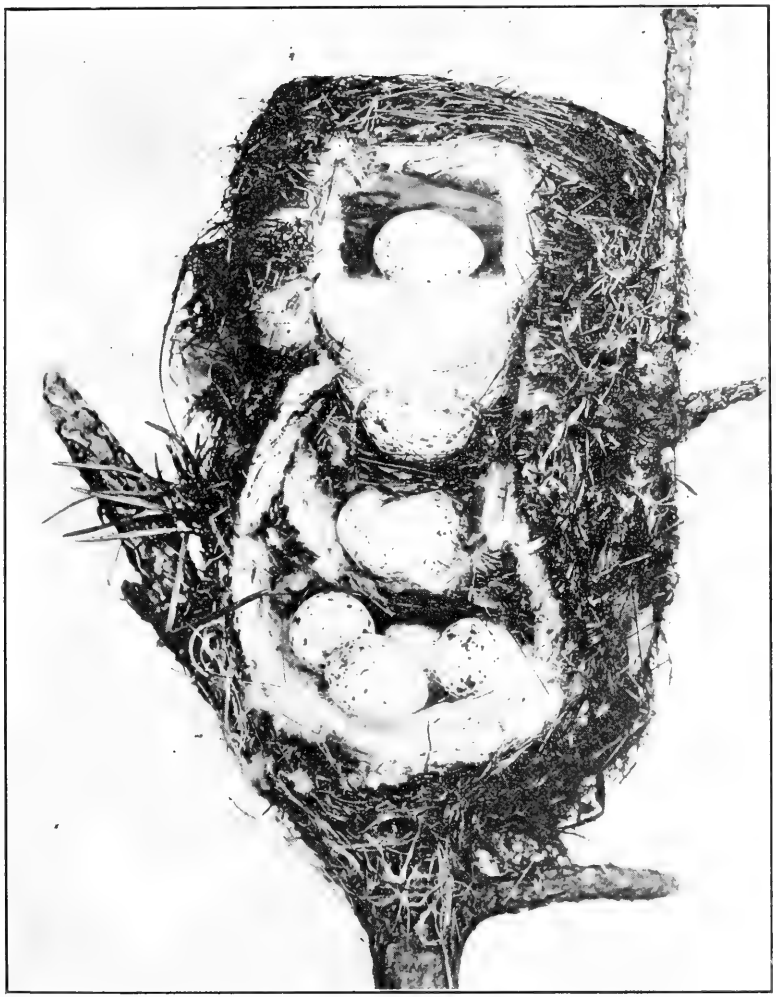


FIG. 22. A MULTIPLE—FOUR-STORIED NEST OF THE YELLOW WARBLER (*Dendroica Æstiva*), with a "parasitic" cowbird's egg in each compartment, but with proper eggs in the first story only, illustrating the successive breaking of the breeding cycle through fear, the beginning of three new cycles in succession, the new nest being built in each case, and probably through association, on the site of the old, thus admirably "concealing" the successive parasitic eggs. Original in the Field Museum of Natural History, Chicago.

The migratory impulse seems to "overlap," and finally to replace the proper parental instincts. The cycle is scamped near its close.

A classical illustration of this struggle of instincts was furnished by Dr. Jenner, in his "Essay on the Migration of Birds," published in 1824, and by the more circumstantial account given by Dr. John Blackwall in 1834, who called particular attention to "the occasional desertion of their last hatched broods by the swallow and house martin." Blackwall was a keen and discriminative observer, but his work[4] is so little known that I shall give a summary of his valuable and interesting results, under this head.

The swallow arrives at Manchester, England, about April the fifteenth, and the house martin on the twenty-fifth of the same month. They produce from two to three broods in the season, and are commonly found with nestlings in October, at a time when most of the migratory species have left the country. Many of these young which are led out of the nest, are deserted before they are able to follow their parents south, and have been found in a state of semi- or total exhaustion, late in the year. This, as Blackwall ingeniously suggests, may have given rise to the queer notion that the European swallows passed the winter season in a state of torpidity.

Blackwall's observations were begun as early as 1821, and when on November 11, 1826, twenty-two nests under the eaves of a barn in the Chapelry of Blakeley were carefully inspected, it was found that thirteen of this number contained either eggs or dead nestlings; five nests held eggs in every stage from the freshly laid to those at the hatching point, while the eight with young showed nestlings in every condition from that of hatching up to the nearly fledged state.

While the female swallow may exceptionally linger longer than the male, it should be noted that both parents commonly abandon their young at the same time. The same fatal conduct was also frequently observed in the sand martin, and Gilbert White, of Selborne, has given an interesting account of a swift, originally noted by him in 1781, which renders it practically certain that this bird may also desert its young, when the migratory impulse is strong. According to Pennant, who is quoted by Blackwall, the puffin is in like case also. The parental instincts of the puffin are strong, and the first young, which appear early in July, are guarded with the utmost care. But strong also is the instinct of migration, and when this emerges punctually at about the eleventh day of August, any young puffins which can not fly are left to the tender mercies of the peregrine falcon. This vigilant plunderer watches at the mouths of their holes, ready to seize them with mailed foot the moment hunger forces them to surrender. We may be quite sure that the young of the species enumerated above are not the only victims of the struggle of conflicting instincts. I have heard of similar behavior on the part of the domestic pigeons.

[4] "Researches in Zoology, Illustrative of the Manners and Economy of Animals," London, 1834; 2d ed., London, 1873.

III. Multiple and Superimposed Nests

We have referred to the towering ærie of the eagle and osprey as being, so far as instinct is concerned, a series of superimposed nests; indeed, any nest built on the site or over the ruins of a former abode, might be regarded in this light. When attachment to the site is strong, the bird, like the peasant in ancient Egypt and many of the earlier races of mankind, builds anew on the ruins of his former home, without taking care to clear the ground or raze such parts as still exist. The result is similar in either case—a series of superimposed structures of different ages, the height to which the pile may rise, depending upon the number of times the same site has been used.

The building of nest on nest, or of new nest on the site of the old, according to this interpretation, gives rise to the wonderful storied structures sometimes produced by the yellow warbler, or vireo, when plagued by the cowbird. That the intruding egg is buried out of sight is not due, however, to a feat of reason on the part of the suffering bird, but is the curious result of a nearly pure instinct, modified only by association. Fear breaks the cycle, but it is not always strong enough to break the habit of going to the old site. Instead of two or more supernumerary nests, more than one of which may contain eggs, and even stand side by side, as has been reported in the case of the phœbe, we have a series of *superimposed* nests, as is clearly illustrated in the remarkable four-storied structure of the summer or yellow warbler, here shown (Fig 22).[5] Each section of this composite, moreover, is seen to contain an egg of the parasitic cowbird, that in the first story being partially concealed by the warbler's eggs present.

According to this view, the new nest is not built *to conceal* the cowbird's egg, although it does so perfectly, any more than the addition of new materials to an osprey's nest in the fall is of the nature of repairs, although it may answer such a purpose admirably. The nest is built or "repaired" because the bird is at the opening of a new cycle, and is impelled to action by the rise of the building instinct. Whether the new nest is built upon the remains of the old, or close beside it, or half a mile away, must be attributed to the ordinary workings of instinct, modified by association and fear, when for some cause the normal cycle has been disturbed.

The so-called "cock nests" of the little marsh wrens may prove to be only another illustration of the supernumerary nests given above, but no opportunity has yet been offered to study these interesting structures. The fact that they may be used secondarily as sleeping apartments, if this is really the case, has no special significance. I have seen the abortive hole of a kingfisher so used, but a few rods from the

[5] For the use of this photograph I am indebted to the courtesy of Mr. F. J. V. Skiff, director of the Field Museum of Natural History, Chicago.

bank, which was later successfully drilled and occupied by the same pair.

The subject of compound nests is too long and involved for full discussion here, but from the builder's standpoint, which is that of instinct, I think there is ground for regarding such a composite structure as that reared on the cooperative plan by the ani or Savanna blackbird, as in reality a multiple nest.

IV. Eccentric Behavior; Robin offering String to Young

Under this head we shall describe a special case of what we have frequently referred to as the "overlap" or struggle of competing instincts. The incident happened in a neighbor's yard on One Hundred and Second Street, Cleveland. A pair of robins had nested in this yard, and successfully reared young, which were then hopping about in the speckled-breasted stage, and begging for food. On a certain occasion one of the parents was seen offering a long piece of twine to one of the youngsters, and trying to cram it into its throat. This robin would repeatedly gather up the string, as it would the coils of an angleworm, and offer it in the usual way, but string not being to the taste of this fledgling, it was as often rejected. After a time the old robin flew with the string into a tree.

With these facts in view, how shall we interpret such extraordinary behavior? We consider this case of the robin a most unusual and interesting exhibition of the conflict of opposing instincts, for according to this idea, the bird was at the close of an old reproductive cycle, and the beginning of a new one. She had fallen, as it were, between two stools. Impelled by the rising instinct of nidification, she gathered the string, when aroused by the calls and sight of her young she was induced to offer it; again under the sway of the building instinct, she flew with the string to a tree. We can judge of the sequel, although unfortunately observation on the robin's conduct stopped at this point. The popular interpretation that the bird was crazy gives place to something which we can measurably understand, or coordinate with other related facts. On the other hand, what a commentary such an act furnishes upon the effective intelligence of birds, when under the sway of powerful instincts. Does not the robin know a "hawk from a handsaw," or a worm from a piece of string? The behavior of the great herring gull with chicks still requiring her care, in going through all the motions of nest-building, and returning to her young again, would seem to be similar in all essential respects.

V. Premature Laying of Eggs, Omission of Nest-building and Parasitism

Lack of attunement between the appearance of the nest and eggs, or terms 3 and 4 of the cycle is very common. Too frequently the egg

"anticipates" the nest. Every one who has given much attention to the activities of birds in the field must have found isolated eggs lying on the ground. Such prize packages are probably more common than we might be led to suppose, for they can not long exist wherever snakes, rodents and other prowling animals abound.

With most birds the act of prematurely dropping an egg can be only a sporadic or casual variation. Without doubt, in the course of time a proper nest is built; eggs are laid, and the normal cycle is rounded out to completion. It is quite possible, on the other hand, that all such eggs are not immediately neglected, but that they are sometimes carried away, and "concealed" by dropping them in another bird's nest, although we have no observation to support such a view directly. It is known, however, that certain birds, such as the black-billed cuckoo, will upon disturbance remove its eggs from the old nest to a new one or to a place of safety.[6] It is also certain that the premature egg is at times laid direct in another bird's nest, which the intruder will often strive to possess by force, and may even succeed. Thus, Davidson, who is quoted by Bendire, found a black-billed cuckoo and a mourning dove sitting on a robin's nest together. This nest was in reality double, and contained two eggs each, of the cuckoo and dove, and one of the robin. The cuckoo managed to get possession of the nest before the robin had finished her work, and filled it with rootlets, but the robin held its ground long enough to deposit an egg. The fact that the cuckoo had "filled it nearly full of rootlets" is a very interesting circumstance, for it shows how completely instinct held the reins of action. This robin's nest seems to have served as a site on which the cuckoo strove to erect one of its own. The dove, noted for its strong parental instincts, had evidently come last, and her eggs were the only ones in which incubation had not begun.

Such a case seems to present us, as in a picture, with one of the steps in the process through which the most remarkable of all the known instincts of birds, that of parasitism, has been brought about.

Certain cowbirds of the new world and cuckoos of the old steal the nests of other birds, but usually only long enough to deposit an egg of their own, which is left to its fate. If tolerated, as is apt to be the case, the stranger is hatched with the other eggs, and the owner of the nest assumes the rôle of nurse or foster-parent. If a cowbird, the foundling soon smothers the proper young, and if a cuckoo, it evicts them. The cuckoo seems to react to a contact stimulus of a disagreeable kind, and when from one to three days old, while still blind, it strives to get egg or nestling on its broad, depressed back, and

[6] That other species of birds occasionally remove their eggs when disturbed can not be doubted, and they probably do it with their bills. The king penguins of the Antarctic are said to guard their single egg by carrying it in a pouch or fold of the skin, developed in either sex, between the legs.

hitching its way, thus laden, up the wall of the nest, throws them overboard. If such a bird is replaced after a time, the same movements are repeated. With the coast thus clear, the little "parasite" can monopolize the attention of its nurse, and grows apace, being attended with all the care which is bestowed on a legitimate child. As Philemon Holland has quaintly rendered the account of the elder Pliny:

"And this yong Cuckow being greedy by kind, beguiling the other yong birds and intercepting the meat from them, groweth hereby fat and faire-liking: whereby it comes into speciall grace and favour with the dam of the rest, and nource to it. She joieth to see so goodly a bird toward: and wonders at her selfe that she hath hatched & reared so trim a chick. The rest, which are her owne indeed, she sets no store by, as if they werr changelings: but in regard to that one, counteth them all bastards and misbegotten." Having followed our elder worthy thus far, we should give his sequel also, even if he steps from observation to fable: "yea, and suffereth them to be eaten and devoured of the other even before her face: and this she doth so long, until the yong cuckow being once fledge & readie to flie abroad, is so bold as to seize on the old Titling, and to eat her up that hatched her."

It is evident that this practise of nest-stealing, somewhat ambiguously called "parasitism," could never become very popular or widespread, for it would soon break down of its own weight.

For over two thousand years, or since the time of Aristotle, who was the first to leave a permanent record of this propensity in the European cuckoo, the question has been asked, How could such a habit arise? and the answers have been various, and far from satisfactory. The key to the matter lies, as we believe, in the cyclical instincts, and in the disturbances to which they are prone. When the normal rhythm is generally disturbed or permanently changed, new instincts and even new structures may arise, which serve as a counterbalance to the changes wrought.

We believe that the instinct of parasitism got its start through lack of attunement in terms 3 and 4, of the reproductive cycle, and that it has passed through essentially the following stages: (1) The egg forthcoming before there is a nest ready to receive it, a condition sporadic in very many, if not in most modern birds, due to unknown causes, such as lead to a premature growth of the ovary, or to a disturbance of certain instincts. There is a loss of eggs, although a nest may be eventually built, and young reared in the season. (2) The eggs are ready before the nest, and many are lost by dropping them on the ground, while others are laid in stolen nests. A proper nest is sometimes built, but whether young are ever reared, will depend upon circumstances. This stage is exemplified by the Argentine cowbird (*Molothus badius*), described by Hudson, which commonly wastes its eggs, scattering them in all directions, yet it will steal a nest upon

occasion, or build one of its own. It even laid eggs in artificial nests, which Hudson placed in trees to test its propensities in this direction. (3) The common practise of stealing nests of other birds, but of holding them, as a rule, only for laying its own eggs, as illustrated to-day by the North American cowbird (*Molothrus pecoris*). The instincts of the intruder seem to be satisfied by "concealing" its eggs, or simply laying them against the wall of another bird's nest, and leaving them. At this stage the European cuckoo, we may suppose, not only frequently dropped its eggs on the ground, but occasionally tried to incubate them, and may have even attempted a rough nest. At this stage also the normal tendency to lay eggs at daily intervals was possibly disturbed, and the interval became irregular, with the gradual establishment of a longer rhythm.

At this point several roads would seem to be open, for the resources of nature are not limited to one course. Parasitic or non-brooding cuckoos have "chosen" one, so to speak, the brooding American species another, and if we are to accept the accounts, certain owls, which breed in the far north, successfully rear young in the short Arctic summer, with an interval of a week or more between each egg. Yet there can be little doubt that an undue lengthening of this interval would seriously interfere with nest-life in many species, and break the tendency to guard the egg. All would seem to depend upon the correlated instincts of parent and child. With an interval of from five to seven days, which has been credited to *Cuculus canorus,* self-brooding would be impracticable without a change in its instincts, for it migrates in July. While it is certain that the egg-laying interval was gradually extended in this bird, it is not known at what corresponding point the parasitic practise was finally established. Certain it is, however, that then as now, the egg, whether laid direct in a nest or dropped on the ground and subsequently conveyed to one, was abandoned. The American brooding cuckoos (*Coccygus erythropthalmus* and *C. americanus*), although suffering a similar disturbance in the brooding interval (of one to three days), have adjusted these differences by another course. The young which are hatched in succession, also leave the nest in succession, when one week old, and enter upon a climbing stage which lasts a fortnight. In this way the brood is divided into two groups, and any untoward effects which might result from a marked difference in age of the nestlings, is avoided. The greatest disadvantage of such a mixture, in the nest of this species, would seem to lie in the fact that the oldest and strongest usually succeed in holding up most of the food. We may add that the American cuckoos have never advanced far beyond the first stage, as designated above, although they have suffered a disturbance in the normal rhythm of egg-production, and that the parental instincts are as strong with them as in passerine birds. The

study of their habits gives no support to the idea advanced by Darwin, in his "Origin of Species," that they are passing along the same road to parasitism already traversed by their European relative. I do not know whether the American cuckoos ever built a better nest or not, but it is certain that the present structure is adequate to their needs, and affords no evidence of a waning instinct of nidification. (4) The final stage of the parasitic instinct among the Cuculidæ is presented by their famous European representative, *Cuculus canorus,* in which the instincts of both young and adult have become so specialized that to describe them at all adequately would require many pages. One hundred and nineteen different species of birds have been the prey of this parasite, the eggs of which have become reduced in size and highly variable in form and color. The commonest dupes are birds of small size, like the hedge sparrow and titlark; but one egg is laid in the same nest by the same bird, and this is often similar in size and coloring to those of the prospective nurse. The egg is deposited stealthily in the stolen nest, and in the absence of the owner, either just before or just after the proper eggs have appeared, or it is first dropped on the ground and conveyed to the nest in bill or gullet, by which the range of accessible nests is greatly increased. These and other remarkable practises of this bird have been fully described in a paper on the "Life and Instincts of the Cuckoo," shortly to appear.

All travelers who have studied the ostriches of South America and Africa in the field speak of the great numbers of their eggs which are annually wasted both in and out of season by dropping them over the plains or around their nests. If this is a secondary character, it must have come from a disturbance of the normal cycle, quite similar to what we have found in cuckoos and starlings. In this case adjustment seems to have been effected in quite a different manner, for we find the male taking upon himself almost the whole duty of incubation and care of the young. Even the wasted eggs, at least in the neighborhood of the nest, serve a secondary use as food, for the young soon break them open and devour them.

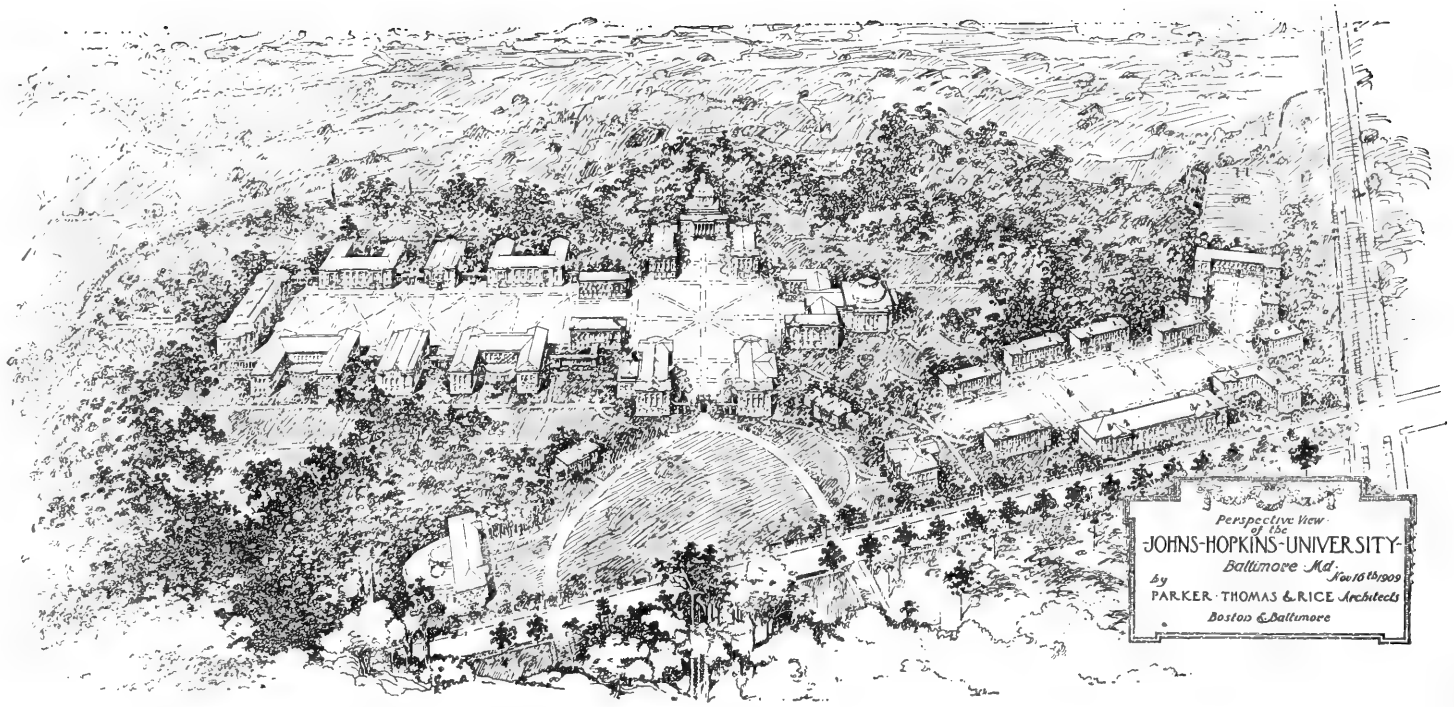
We can not discuss with much profit the remarkable breeding habits of the megapodes of Australia and the East Indies, referred to earlier in this paper, until naturalists have made more detailed studies upon the various species. The notes which follow are purely tentative, and are offered by way of suggestion. The true megapodes build huge mounds of earth and leaves, which serve as incubators for their eggs, and the young, which may or may not be subsequently tended by their parents, are in most cases able to run or fly from birth, or when they emerge from their mound. The moleos or "maleos" deposit theirs in black volcanic sand which is both damp and warm, either by the seashore or in the vicinity of warm springs in the interior. In any case

both birds instinctively secure the two requisites for successful incubation—even warmth and moisture—though in different ways.

That the brush turkeys are descended from stock which possessed the instinct of incubation is rendered probable from the fact that they are gallinaceous birds, allied to the curassows, wild turkeys and grouse, all of which build some kind of a nest and brood their young at the present time. Further, the fact that the same mound is used continuously by the same birds, whether by more than one pair or not, and is added to year after year, like the ærie of an eagle, and that in the ocellated megapode, at least, the adults remain in the vicinity of their mound and tend their young after leaving it, all suggest that this mound must be regarded in the light of a nest, however modified from the typical structure. From the stage seen in the ocellated magapode, it is only a step or two to that found in others, where the parents never see their young, for which they make ample provision, any more than does a turtle or a mud-dauber wasp.

More aberrant still, but in the same direction, is the behavior of the moleo, in which as in the parasitic cuckoos, other changes have arisen, which would render self-brooding difficult if not impracticable. Their large eggs, six to eight in number, are said to be deposited at the extraordinary interval of ten to twelve days, so that a period of three months would elapse, between the laying of the first and last. Again, unlike the fowls and birds generally, no turning of the eggs during incubation is necessary.

While nothing is certainly known concerning the history of these peculiar instincts of the megapodes, it is not unlikely that, as in cuckoos and cowbirds, they have arisen through the modification of earlier and more uniform instincts which the ancestors of all modern birds seem to have possessed in common.



A Perspective View of the Proposed Buildings on the new Site of the Johns Hopkins University.

THE PROGRESS OF SCIENCE

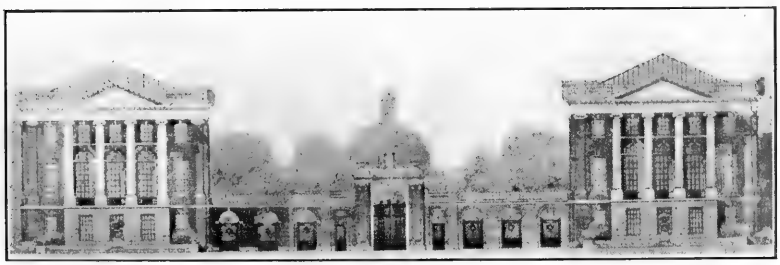
THE JOHNS HOPKINS UNIVERSITY

THE authorities of the Johns Hopkins University have issued a pamphlet in the interest of the endowment and extension fund which they need and should have. The General Education Board has undertaken to contribute $250,000, on condition that $750,000 be obtained from other sources: but the university aims at more than this. It would remove to its new site and would complete its university organization by the establishment of a school of higher engineering, a law school maintaining the standards of its medical school, and a school for the training of teachers. It would also obtain an endowment fund for its college, establish a department of preventive medicine and erect a building for pathology.

When the Johns Hopkins University celebrated the twenty-fifth anniversary of its foundation in 1902 a site was given to it which cost $500,000, and is now worth twice as much. The hundred and twenty acres, finely situated two miles from the center of Baltimore, admit of picturesque development beyond the possibilities of any other city university. We reproduce a plan of the site with pictures of two of the buildings which it is intended to erect first and of the Carroll mansion on the grounds, which is to serve as a model for the architecture. A botanical laboratory and garden and an athletic field are already in use. The administration and academic buildings, shown in the illustration, and laboratories for chemistry, physics, geology and botany must be erected promptly. These with the power plant, grading, etc., will cost about $1,200,000, towards which can be used the proceeds of the sale of the present site and buildings.

So long as a national university is not established in Washington, there is needed a great university at Baltimore. The states to the south and west are not adequately supplied with institutions of higher learning, and for a long while the Johns Hopkins University will set a model for that region, whose industrial development will surely be followed by an intellectual renaissance.

The Johns Hopkins University deserves well not only of Baltimore and Maryland and the south, but of the whole country. When it was opened on October 3, 1876, there were colleges in this country, but no universities. The idea of the university was doubtless in the air, but it was first placed on a solid foundation at Baltimore. Remarkable wisdom was shown by



ADMINISTRATION AND ACADEMIC BUILDINGS WITH ENTRANCE TO QUADRANGLE.

THE CARROLL MANSION AT HOMEWOOD, built in 1803, the architecture of which will be the key-note for the new buildings.

President Gilman and his advisers, not only in deciding that the Johns Hopkins should be a university rather than a college, but also in adopting standards and ideals, which have not elsewhere been paralleled. The smallest possible amount of money was spent on buildings, and no attempt was made to cover all kinds of subjects. A small group of professors, each a man of distinction—Rowland, Remsen, Sylvester, Martin, Brooks, Gildersleeve—were brought together, adequately paid and given complete freedom. Fellowships and means of research and publication were provided; the ablest students in the country were drawn to Baltimore. These men are now in nearly every academic center of the country, and the influence of the Johns Hopkins and of the university ideal is everywhere.

Not only in 1876, but again in 1893, and again with comparatively modest resources, the Johns Hopkins set university standards by the establishment of its school of medicine. Again a small group of distinguished men—Welch, Osler, Howell, Mall—were brought together, and for the first time in this country there was a school of medicine on a proper university basis. Like the graduate faculty of philosophy this school has set a model, which other institutions are now following.

The country can only in slight measure repay the Johns Hopkins University for its great service by giving it the money it now needs. Columbia and Princeton have each received $5,000,000 within the past year; the Johns Hopkins should have as much. If the writer of this note—who is one of those who came under the influence of the university in its great days—had despotic control of the vast wealth of the country, he would assign to the Johns Hopkins University as many millions as it might ask. But it would not be for new buildings and new departments. It would be on condition that the standards set in 1876 and 1893 should be maintained, that we should have a university where every teacher is a great man, free to do his own work in his own way.

MEDICAL EDUCATION IN THE UNITED STATES

THE Carnegie Foundation has issued a bulletin on medical education in America, which is likely to do good service in attracting attention to the low standards and inadequate endowment of many of the medical schools of the United States. On behalf of the foundation, Mr. Abraham Flexner has visited every one of the 155 medical schools, and gives a brief description of each. The conditions in each state are summarized, and plans are proposed for their improvement. This detailed report is preceded by an introduction by President Pritchett and by fourteen chapters by Mr. Flexner on the whole subject of medical education in this country, beginning with a historical sketch and ending with the education of the negro. The bulletin, which extends to 347 pages, may be obtained by sending seventeen cents for postage to the foundation.

The conditions of medical education in the United States have been investigated with equal thoroughness by the council on education of the American Medical Association, and are well understood by experts. There are too many inadequately trained physicians in the country, and one of the principal difficulties is the existence of proprietary schools dependent on the fees of students. Physicians are ready to be professors in medical schools for the title and connections. When the school depends for its support on the fees, low standards are likely to be adopted in order to attract students. It was at one time possible to conduct a proprietary school with tolerable efficiency, as can now be done in the case of law, but with the development of laboratory and clinical methods, the cost of a satisfactory medical education can not be met by fees. It is certainly a scandal that one third of our medical schools have incomes below $10,000, all from fees, that in some cases there are as many professors as students, and that many students do not have even a high school education. One school actually exists with twenty-six professors and a total income of $1,060.

But while every one knows and admits the evils, the remedy is not clear. Though Dr. Pritchett and Mr. Flexner have obtained their medical education by a short course, they have had expert advice and their general point of view is sound. We need several university schools of medicine emphasizing research and demanding long preliminary preparation, the schools for the training of the great mass of practising physicians should require a training in science and the languages equal to two years of college, the schools in the south can not at present reach this standard, but should require a preparation equal to a four-year high school course. Each school should have adequate laboratories for anatomy, physiology, chemistry and pathology under the charge of professors and instructors who give their whole time to the work of teaching and research. The clinical departments should be under the charge of professors whose practise does not interfere with their teaching, and there should be a suitable hospital and dispensary controlled by every school.

But how are we to reach these standards? We are slowly approaching them. When the Johns Hopkins Medical School was opened seventeen years ago, it was the only well-organized department of medicine in the country. With Harvard it still maintains preeminence; but there are now some thirty schools which give adequate training for the medical profession. The commercial schools are closing and being merged every year, for by the nature of things they can not last when they do not pay. When good schools are adequately endowed in all sections of the country, students will naturally frequent them. The states can accomplish more for the profession of medicine and the people by support-

ing good medical schools than by suppressing those that are poor or by formal restrictions making it difficult to enter the medical profession.

ROBERT KOCH

In the death of Robert Koch, the world loses one of its greatest men, whose service to it has been beyond all measure. It is not easy to realize the changes in bacteriology and in medicine which have taken place in the course of the past thirty or forty years, or how largely these are due to this one man. Koch was preceded by Pasteur and Lister, but bacteriology and the germ theory of disease scarcely existed when in 1876 he published his paper announcing the isolation of the bacillus of anthrax. He was at that time a country physician, but had had the advantage of studying medicine at Göttingen under Wagner and Henle. One wonders whether the hundred and twenty-five thousand physicians now practising in the United States would not produce some men of the type of Koch if they had been turned in the right direction at the university. If so, how small would be the cost of such schools in comparison with their value.

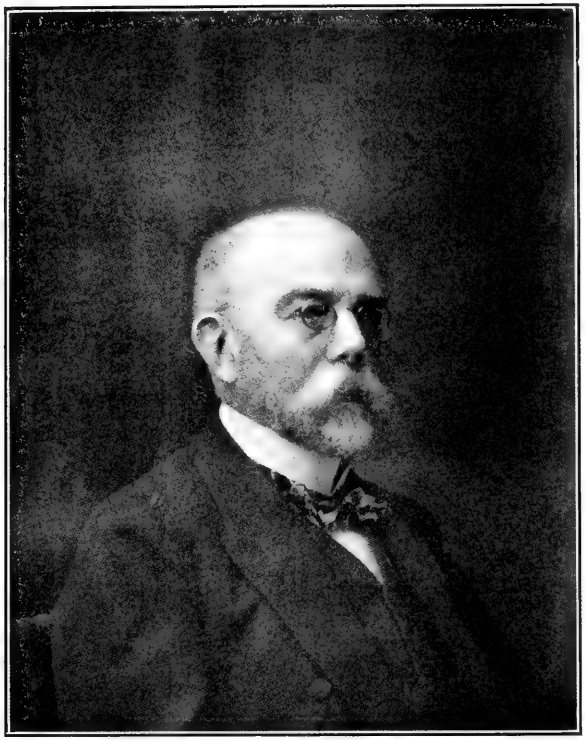
Koch published in 1878 a second important paper on infectious diseases, and was in 1880 given opportunity to devote himself to research work by being appointed to the Prussian department of public health. In his small laboratory at Berlin, with Loeffler and Gaffky as assistants, he developed the methods of bacteriology by cultures and disinfection, and in 1882 made announcement of the far-reaching discovery of the bacillus of tuberculosis. A year later he visited Egypt and India and discovered the comma bacillus of cholera.

Koch continued his study of tuberculosis, cholera and other diseases, not only from the point of view of laboratory science, but devising and applying means to combat them. In 1880 came the discovery of tuberculin, the curative power of which was exaggerated, not so much by Koch as by the general public. Koch was fully justified by its diagnostic value; his statement of its curative properties was cautious, and if it has not fully justified even these modest claims, it has led to the whole subject of vaccine therapy, including diphtheria anti-toxin, and may still fully confirm such claims as Koch made for its curative value in tuberculosis. Koch was again criticized when in 1901 he announced the discovery that human and bovine tuberculosis are not identical, but time appears to have proved that he was correct in his facts and also in his claim that the main efforts should be directed toward preventing human contagion.

In later years Koch devoted himself largely to tropical diseases and accomplished much by his studies in Africa and Asia of parasitology, bacteriology and hygiene, investigating rinderpest and surra, the bubonic plague, malaria and sleeping-sickness.

Such rewards as a scientific man may have were given to him. He was appointed in 1885 professor of hygiene in the University of Berlin and director of the Hygienic Institute, then newly established. In 1891 he was appointed director of the new Royal Institute for Infectious Diseases, and became an honorary professor in the university. This institute now forms a part of the Rudolf Virchow Hospital, and is known as the Koch Institute. Koch received the Nobel prize in medicine in 1905. But the rewards that could be given to him were insignificant beside his services.

Of the world's debt to Koch the *Journal* of the American Medical Association says: "But death has claimed the master and the world has lost its leader in the struggle against infection. Endowed with a mind of the first order, and animated, beneath a quiet, impassive and meditative exterior, by a spirit of unceasing but wonderfully well-regulated activity, which drove him on as by an internal



ROBERT KOCH.

fire from achievement to achievement, he made his own age preeminent over all the ages that have gone before for advances in the exact knowledge of the causation and prevention of infectious diseases. Rarely, if ever, have so many discoveries of such decisive importance to mankind emanated from the activities of one person; yet he served with all humility of mind. He simply tried to do his duty, being, as he said, fortunate to find sometimes the gold among the gravel of the road which is open to every one. When we consider the advancement medicine owes to Robert Koch and the endless and inestimable blessing which has come to mankind through his work and life, there comes an overpowering sense of admiration, reverence and gratitude."

SCIENTIFIC ITEMS

WE record with regret the deaths of Dr. George Frederic Barker, emeritus professor of physics in the University of Pennsylvania; of General Cyrus Ballou Comstock, U. S. A. (retired), the eminent engineer; of Professor William P. Blake, known for his contributions to geology; of Professor Stanislau Cannizzaro, the distinguished Italian chemist, and of Lieutenant Boyd Alexander, the African explorer.

NEW YORK UNIVERSITY has given its doctorate of laws to Dr. Henry Mitchell MacCracken, who retires from the chancellorship of the university.—Sir David Gill, K.C.B., F.R.S., has been appointed a knight of the Prussian Order of Merit.—Lord Rayleigh has been promoted from a corresponding to

a foreign member of the Berlin Academy of Sciences.

Following the advice of its advisory board, the Wistar Institute of Anatomy has established a department of embryology, and Professor G. Carl Huber, of the University of Michigan, has been called to this chair.

By the will of Isaac C. Wyman, of Salem, Mass., a graduate of Princeton College, most of his estate is bequeathed to Princeton University, to be used for a graduate school. Mr. John M. Raymond, of Salem, Mass., and Professor Andrew F. West, dean of the Graduate School, are the trustees. The value of the bequest is estimated at $3,000,000. Mr. W. C. Procter has renewed his gift of $500,000 for the Graduate College. A great graduate school is thus assured at Princeton.

At a meeting of the trustees of the General Education Board, held on May 24 in New York City, $682,450 in appropriations was voted. Of this sum $538,000 was appropriated conditionally for the endowment funds of eight colleges, $113,000 for the furtherance of demonstration work in agriculture throughout the southern states, and $31,450 for the salaries and expenses of special professors of secondary education in the several state universities of the south. The appropriations voted in support of college endowments raised to $5,177,500 the sum already spent in this direction. The seventy colleges that have received these endowments during the last four years of the board's activities have each raised sums in endowment which, taken with the board's gifts, aggregate $23,670,500.

THE
POPULAR SCIENCE
MONTHLY.

AUGUST, 1910

THE PAST AND PRESENT STATUS OF THE ETHER[1]

By Professor ARTHUR GORDON WEBSTER
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IN a recent letter to the New York *Nation,* Professor William James, in describing the philosophy of M. Emile Boutroux, makes the statement that "theories result from psychological variations, just as Roosevelts and Rockefellers result from biological variations." Of the entities of science he says:

> The creative touch of human reason was needed in each case for the extrication; and that those particular creations resulted rather than a hundred others just as possible, is one of those selective interactions between living minds and their environment which can be "understood" when once it has occurred, but which no acquaintance with the previous conditions can show to an outsider that it was the sole thing possible.

Considering the prevalence of such philosophical views, and the fact that many persons believe that physics is now undergoing a sort of crisis, in which many of our most cherished ideas are about to be relegated to the scrap-heap, I believe it to be not without profit to consider the past and present condition of our views with regard to the luminiferous ether, and to cautiously forecast their future.

Certainly the postulate of the existence of the ether has been until very recently one of the fundamentals of physics (including astronomy). At the congresses of arts and sciences held at St. Louis in 1904, the subject of physics was, like all Gaul, divided into three parts, physics of matter, physics of ether, physics of the electron, and although this division was, I believe, not made by a physicist, this must have made little difference. In an interesting book published less than a year ago by Sir Oliver Lodge, entitled "The Ether of Space," the properties of the ether are set forth with a concreteness and dogmatic manner that is now becoming unfashionable, and relieves that writer

[1] Read at a meeting of the American Philosophical Society, April 22, 1910.

from any suspicion of being called a pragmatist. For him the ether undoubtedly is a real thing. In a more ambitious treatise published ten years ago, by Sir Joseph Larmor, entitled "Ether and Matter," we have a thoroughgoing mathematical investigation of the properties of the ether, and, as the subtitle states, a development of the dynamical relations of the ether to material systems. And yet, since the publication of the latter work there have been voices heard with ever-growing distinctness, declaring in not dubious terms the lack of necessity of any such conception as that of the ether, and threatening the belief in its existence with relegation to the company of phlogiston in the morgue of dead theories. That we can not dismiss such voices with contempt is evident if among them are to be counted those of such leaders of physical science as Henri Poincaré, Sir J. J. Thomson and Professor Max Planck.

Before we can discuss the question of the existence of the ether, we must first determine what we mean by that term. This is undoubtedly the main difficulty with the whole matter. The article in the "Encyclopædia Britannica," written over thirty years ago by Maxwell, as competent an authority as could have been named at that time, begins with the definition, "a material substance of a more subtle kind than visible bodies, supposed to exist in those parts of space which are apparently empty," and ends with the statement, "Whatever difficulties we may have in forming a consistent idea of the constitution of the ether, there can be no doubt that the interplanetary and interstellar spaces are not empty, but are occupied by a material substance or body, which is certainly the largest, and probably the most uniform body of which we have any knowledge." This is certainly flat-footed enough, but how different from the conclusions of Lodge, one of the present survivors of the same school, we may see from his book above mentioned.

The need for the idea of an ether is well shown by the following quotation from Newton, who, after describing an experiment of two thermometers, one in a vessel filled with air and the other in vacuo, being carried from a cold place into a warm one, both rising at the same rate, says:

> Is not the heat of the warm Room conveyed through the Vacuum by the Vibrations of a much subtiler Medium than Air, which after the Air was drawn out remained in the Vacuum? And is not this Medium the same with that Medium by which Light is transmitted, and by whose Vibrations Light communicates Heat to Bodies?

And yet Newton did not accept the wave theory, but by the influence of his great name bolstered up the emission theory for a hundred years. It was his contemporary Huygens, who must be credited with the invention of the ether in order to explain the propagation of light. Huygens's ideas of the properties of the ether were, however, very dif-

ferent from those that have now been held for a century. In order to cover all the different notions that have been held, without being so definite in making the ether a substance as was Maxwell, we need only ask the question, Since we know that light travels with a speed of about three hundred thousand kilometers per second, and takes about eight minutes to come from the sun, what is the state of the light after it has left the sun and before it has reached the earth? We reply, it is traveling through the ether. A similar definition was given by the late Lord Salisbury who said that the noun ether was the subject of the verb to undulate. But why undulations? The undulatory theory, as a successful explanation of optical phenomena, is just about a century old, and was propounded by Dr. Thomas Young, in two Bakerian lectures before the Royal Society in 1801 and 1803. The reason that convinced Young, and later the scientific world, of the undulatory nature of light, was the fact of interference, or the production of darkness by the simultaneous action of two beams of light, carefully investigated by Young. These views were savagely assailed by Lord Brougham, in a scurrilous article in the *Edinburgh Review,* in which he says that "it is a metaphysical absurdity, to assert that qualities can move in concentric surfaces." The violence of the attack may be seen from the quotation:

> The long silence which he (Young) has since preserved on philosophical matters, led us to flatter ourselves, either that he had discontinued his fruitless chase after hypotheses, or that the Society had remitted his effusions to the more appropriate audience of both sexes which throngs around the chairs of the Royal Institution.

It is evident that Young had an excellent understanding of the analogy between sound and light waves, but he did not follow out the theory with the mathematical exactness bestowed upon it by Augustin Fresnel, whose superb researches, beginning in 1815, have made his name a classic of optical investigation. Both Young and Fresnel recognized, as Huygens had not, the fundamental difference in the nature of waves of light and sound, namely, that since by turning the proper apparatus traversed by light about the direction of the beam as an axis, the light is capable of alternate extinction and transmission, the undulations must be transverse to the direction of propagation. Fresnel introduced into his mathematical treatment certain mechanical principles, notably that one which we now call the conservation of energy, but he did not attempt to find a mechanical structure, in terms of properties of ordinary matter inertia and rigidity, which would explain the nature of the ether. This was done by George Green, who assimilated the ether to an elastic solid, which is capable of transmitting transverse waves in all directions with the same velocity. Unfortunately, such a solid transmits equally well longitudinal waves, like those

of sound, but with a different velocity from that of transverse waves. But such longitudinal waves have no place in any optical phenomenon, and therefore constitute a difficulty for the theory. In order not to have them it was necessary for Green to suppose the ether incompressible. Thus the theory did very well for the propagation of light on free space. When light passes from free space to a transparent substance, however, it is partially reflected and partially refracted, travelling with a different velocity in the new medium. This change of velocity could be explained by a difference of either density or rigidity in the two media. Green chose one hypothesis, in fact the same as that of Fresnel, Neumann and McCullagh the other. This difference gave rise to a controversy over the direction of the vibration, as to whether it was in or perpendicular to the plane of polarization, a controversy vainly sought to be settled by experiment. Although reflection and refraction could thus be explained, there remained a very grave difficulty. The conditions to be satisfied at the surface between two different media are too many to be satisfied by a transverse wave alone, so that had there been originally only a transverse wave, it would give rise to a longitudinal wave on striking the surface limiting the media. To avoid this difficulty a mechanical theory was proposed by McCullagh, in which the elasticity was not like that found in any known substance, but was called into play when a portion of the medium was rotated, quite independently of whether neighboring portions were rotated or not. This theory gave a very satisfactory explanation of reflection and refraction, but long met with opposition on account of its postulating elastic properties not found in any substance.

Probably the person who took most seriously the view of the ether as having the properties of some familiar sort of matter was Lord Kelvin, who devoted a large portion of his life to the attempt to find a suitable mechanical representation of the ether. In fact he stated on the occasion of his jubilee that for forty years this question had not been absent from his mind for a single day. Lord Kelvin frequently uses the term "jelly" as typical of Green's elastic substance, and did finally, by a very ingenious assumption, succeed in assimilating the ether to such a substance. But in spite of all these attempts, we may agree with the opinion of Lord Rayleigh, who concludes that for many reasons "the elastic solid theory, valuable as a piece of purely dynamical reasoning, and probably not without mathematical analogy to the truth, can in optics be regarded only as an illustration."

Such was the condition of affairs at the close of what I may call the medieval period in optics, when, in 1864, Maxwell gave affairs an entirely new turn by the presentation of his famous paper on "A Dynamical Theory of the Electromagnetic Field." In this he was guided by the conjecture of Faraday that the same medium which is concerned

in the propagation of light might also be the agent in electromagnetic phenomena. Faraday says:

> For my own part, considering the relation of a vacuum to the magnetic force, and the general character of magnetic phenomena external to the magnet, I am much more inclined to the notion that in the transmission of the force there is such an action, external to the magnet, than that the effects are merely attraction and repulsion at a distance. Such an action may be a function of the ether, for if there be an ether, it should have other uses than simply the conveyance of radiation.

This expression of Faraday is the key-note of Maxwell's theory. In examining the properties of the medium necessary to transmit electric and magnetic forces, he concentrates his attention on two quantities having direction, namely, the magnetic and electric polarization of the medium at every point. He shows that these states of polarization are propagated in waves, and that these waves have all the properties of light-waves. They are transverse, no longitudinal wave occurs, and moreover for the first time the conditions at the surface of separation of two media are exactly sufficient to give the proper explanation of reflection and refraction. Everything accomplished by *any* undulatory theory was accomplished by the electromagnetic theory, with this in addition, so that it is perhaps surprising that it remained for the experimental production in 1888 by Hertz of undoubtedly electromagnetic waves having all the properties predicted by Maxwell to give this theory the overwhelming preponderance that it has since maintained.

We may now touch upon the question, what is a mechanical theory. A mechanical theory is one that can be stated in terms of the principles of mechanics. The laws of mechanics, as they have been held since their exact statement by Newton, are all embraced in the single mathematical principle of least action, best comprised in the enunciation of Hamilton. In this enunciation occur two functions representing the two forms of energy, kinetic and potential. If these depend in a certain simple manner on two quantities having direction, or vectors, irrespective of their physical nature, the differential equations follow, which lead to wave propagation. Maxwell's field vectors have this property, and consequently Maxwell's theory *is* a mechanical theory. I will now define the properties of the ether, as they seem to me to be required by our present-day notions. The ether connotes those properties of space in virtue of which a change in either of two field vectors at any point gives rise to a field of the other sort, the lines of which tend to symmetrically surround the lines of the original and varying vector in circles. In addition the direction of these surrounding lines is contrary according to the field that we begin with. This is a qualitative statement in plain English of what is quantitatively stated in the six differential equations of Maxwell's theory, and it avoids the use of the

electromagnetic terminology. It thus applies exactly to Fitzgerald's and Larmor's resuscitation of McCullagh's rotational elastic theory, which is found to be identical with the electromagnetic theory.

I believe that I have thus given that definition of the ether which best agrees with what Boltzmann calls the phenomenological view in physics which attempts to exactly describe phenomena, without any hypothesis, or any attempt at mechanical model to assist the imagination. This was the view of Kirchhoff, Helmholtz, Hertz and Boltzmann, and I believe it to be the most scientific. The English method, of which Lord Kelvin was the leading example, demands concrete models, which resemble the phenomena more or less, and which are frequently changed. In the words of an acute French critic, M. Duhem, for a geometer of the school of Laplace or Ampère, it would be absurd to give for the same law two theoretical explanations and to maintain that the two explanations hold simultaneously; for a physicist of the school of Kelvin or Maxwell, there is no contradiction in the same law being represented by two different models. I may also quote Fitzgerald's words:

> I can not conclude without protesting strongly against Sir William Thomson's speaking of the ether as like a jelly. It is in some respects analogous to one, but we certainly know a great deal too little about it to say that it is like one. I also think that Sir William Thomson, notwithstanding his guarded statements on the subject, is lending his overwhelming authority to a view of the ether which is not justified by our present knowledge, and which may lead to the same unfortunate results in delaying the progress of science as arose from Sir Isaac Newton's equally guarded advocacy of the corpuscular theory of optics.

I feel that this protest is a very mild one, and that the attempt made by Kelvin to determine the density and elasticity of the ether, from very questionable assumptions, together with the recent attempts of Lodge, based on equally naïve conceptions of the nature of the ether as a concrete substance, are greatly to be deplored.

We come now to the most modern development of the ether theory. Maxwell had, as has been said, accurately described the propagation of the electromagnetic waves, and had given the differential equations governing their propagation. It remained to add to these equations terms expressing the genesis of the waves, to show how these resulted from the motion of charges of electricity. This was done in an important series of papers begun in 1892 and continued until the present by H. A. Lorentz, who may be characterized as the legitimate successor of Maxwell. Not only did Lorentz add terms shown to be necessary by the experiments of Rowland on the magnetic effect of moving electric charges, and later by the deflection of the cathode rays by a magnet, but he succeeded in showing for the first time how the potentials determining the field were propagated in time through the field, a result vainly sought by Gauss, Weber and Riemann, and almost

reached by the latter. The object of Lorentz in his papers was to explain the transmission of waves in moving media, beginning with the explanation of astronomical aberration. Singularly enough this was the one phenomenon which was better explained on the emission than on the undulatory theory, and which had proved a stumbling-block for the latter. If the ether is a substance, the question arises whether it is carried along by the earth in its motion, or whether it remains fixed. Lorentz assumed that it remains fixed, and thus satisfactorily explained aberration. But if the earth moved through the ether, the velocity of light between terrestrial points should be affected in the same way that the velocity of sound is affected by the wind. To test this a celebrated experiment was made by Michelson in 1881, repeated by Michelson and Morley in 1887, and several times later, which showed the failure of the earth's motion to influence the velocity of light from a terrestrial source. This classical experiment may prove to be the beginning of the end of the ether. It is evident that if light is propagated through the ether in waves which have a velocity peculiar to the ether, and not influenced by the velocity of the source, then light will take longer to reach a point a given distance from it when both are moving in the direction of the line joining them when the second point is ahead than when it is behind, in the ratio of the sum of the velocities of the source and the waves to their difference. The time for the light to go to the forward point and come back is greater than it would be if the system stood still by an amount inversely proportional to $1-\beta^2$ where β is the ratio of the speed of the source to that of light. In the case of the earth this is about one part in one hundred millions, and it was shown by Michelson that no such effect existed. Michelson assumed that this showed that the ether was fixed to the earth. For the contrary explanation, Lorentz adopted an hypothesis already proposed by Fitzgerald, namely, that all bodies in motion are thereby shortened in the direction of their motion, in precisely this ratio. This hypothesis, though startling, has now obtained great weight. In connection with it, Lorentz introduced the idea of local time, which is different for different points of the same system moving with a uniform velocity of translation. The modification, by the motion, of both distance and time leads to a most fundamental principle for all our physical notions, called the principle of relativity, which, though brought about by Lorentz, was most clearly expounded by Einstein, who is probably the high priest of the ultra-modern school. The principle of relativity assumes as a postulate that all phenomena are the same if observed with reference to a body moving with constant velocity with respect to the ether as if with respect to a body at rest. If this is so, and no experiments have contradicted it, we have as much right to suppose the ether at rest with respect to one body as another. It seems then unnatural to characterize one body as moving relative to a fixed ether. Hence

Einstein abandons the ether, which he declares to be the totally unnecessary conception. Einstein makes two postulates which are sufficient to explain all phenomena now known. The first has been stated, the other is that the velocity of light is the same when measured in any system. By measures of this velocity, we can, therefore, not determine whether the system is moving or at rest. Clothed in a more mathematical form, such as has been given by Minkowski, we may state the principle as follows: If instead of the distance x measured in the direction of the motion of the system, and of the time t measured by a clock standing still, we substitute a quantity x' denoting a new length and t' a new time, then all the equations of electro-dynamics and presumably all those of physics admit of a so-called linear transformation of the variables x and t to the variables x' and t'. Under this transformation, the equations remain, therefore, absolutely unchanged. It is accordingly impossible by any observations to determine whether the time measured by the clock is t or t' or whether the distance measured by the scale is x or x'. As has already been said, this proposition is of the most startling nature and results in connecting the notions of time and space in a most unexpected manner. In fact we may briefly sum up by saying that we can not tell *where* a point is until we know *when,* and we can not tell the time *when* until we know the place where! If we accept this principle it may be necessary to totally abandon the hypothesis of the ether. Certain writers, such as Ritz in France, have established a system of electrodynamics in which the conceptions of the ether and of the magnetic and electric fields have totally disappeared. Ritz, for instance, bases his whole theory upon the so-called retarded potentials of Lorentz, by means of which the action of any electric charge, fixed or in motion, is calculated at any other time and place by means of definite integrals. This conception has been vigorously maintained: in England I may mention the name of Mr. Norman Campbell, who in a recent article in the *Philosophical Magazine,* as in his excellent modern treatise on electromagnetic phenomena, has vigorously assailed and even ridiculed the school of those whom he calls the "etherealists," as making use of a totally useless and hindering conception.

In 1900 Professor Poincaré had already asked the question, "does the ether exist?" This I may characterize as now the question of the hour. To sum up what I believe to be the state of the case, certain phenomena concerning radiation and the distribution of energy in the spectrum have led to the necessity of certain assumptions which seem difficultly explained on the ether hypothesis. Sir Joseph Thomson also, in order to explain certain phenomena connected with the emission of electrons from metals under the action of ultra-violet light and other phenomena with which he is particularly competent to deal, has propounded the hypothesis that a wave of light is not uniform but is somewhat of a fibrous nature. I find it difficult to see how such a hypothesis

is to be reconciled with the hypothesis of the ether or the differential equations at all. In fact, the views of Sir Joseph are to me in many places incomprehensible. In his lectures recently delivered at the Royal Institution on the electromagnetic theory of light, however, Sir Joseph categorically expresses himself as of the opinion that the electromagnetic theory of light is one of the great achievements of modern science. To me this means that he approves of the ether. To take the extreme argument of Ritz, who employs as a fundamental necessity the retarded potential, seems to me to be exactly the same thing as to say that the ether exists, for since nothing whatever is propagated with finite velocity, this is the same to me as saying that it is propagated in the ether. In the first part of this paper, I have defined what I mean by the ether in very guarded form. This definition I see no reason to change. Whether we begin with the retarded potential and find that it satisfies a differential equation, or whether we begin with the differential equation and find that it is satisfied by a retarded potential is to me a matter of utter indifference and implies an ether. I admit that we still have to find a hypothesis for the ether which makes it give rise to this differential equation. The hypothesis of Maxwell seems to me the easiest one yet proposed. I will therefore close by stating my present opinion, that the ether is as good to-day as it ever was, but that apparently the notions of time and space have had to be modified in the method suggested by Lorentz and splendidly developed by Einstein and Minkowski. At the same time, we can not deny that there exists to-day what we may call *la crise de l'éther,* and we are far from being able to say with Lord Kelvin, " It is absolutely certain that there is a definite dynamical theory for waves of light, to be enriched, not abolished, by electromagnetic theory."

PHYSIOLOGIC LIGHT

By F. ALEX. McDERMOTT

HYGIENIC LABORATORY, U. S. PUBLIC HEALTH AND MARINE HOSPITAL SERVICE

THERE are probably but few if any of the readers of this magazine who have not seen and admired at least one of the many manifestations of "physiologic light," of which the most common to us is the firefly. Indeed, from the earliest times the phenomenon of the emission of light by animals and plants has attracted man's attention, and a large amount of scientific work has been done upon the subject. An attempt to compile a complete bibliography of the subject has resulted in the remarkable discovery that there are over seven hundred references to the literature bearing on the emission of light by organized bodies, and "the end is not yet." The work has embraced the physical, chemical, physiologic, histologic and entomologic sides, and much valuable information and many interesting facts have been secured. Among the names of the early writers who refer to some phase of this phenomenon are Aristotle, Pliny the Younger and Josephus; the more recent names include those of Robert Boyle, Sir Humphry Davy, Faraday, Pasteur, Kölliker, Dubois and the late S. P. Langley, and indeed a host of others whose names are more or less widely known. Several extensive treatises on the subject have appeared, some of which are really quite good, though regrettably they are for the most part out of date at this time. For the benefit of those who may care to read further, the names of a few of these are given below.[1]

The phenomenon of physiologic light has been variously termed "phosphorescence," "luminosity," "photogenic function," etc., by different authors. As these are, for the most part, interchangeable in meaning, they will be used in this paper to refer to the same thing. The term "phosphorescence" is unfortunate, since it implies that the light is due to the presence of the element phosphorus—which it is not—and has become still more objectionable recently owing to its application by physicists and chemists to another totally different phenomenon of light emission.

It was my good fortune during the summer of 1909 to be associated with Professor J. H. Kastle, of the University of Virginia (then chief

[1] Holder, C. F., "Living Lights," Scribner's, 1886, New York; Gadeau de Kerville, "Les Insectes Phosphorescents," Rouen, 1881, 1887; Gadeau de Kerville, "Les Animaux et les Vegetaux Lumineux," Paris, 1891 (German edition by Marshall, Berlin, 1893); Dubois, "Les Elaterides Lumineux," Paris, 1886; Dubois, "Physiological Light," Smithsonian Institution, Washington, D. C., Report for 1895, pp. 413–431.

of the Division of Chemistry of the Hygienic Laboratory, of the U. S. Public Health and Marine Hospital Service), in a study of the effects of various chemical agents on the emission of light by the common firefly of the country around Washington, *Photinus pyralis* K. In the progress of this work we had occasion to review the available literature quite thoroughly, and were struck with the lack of acquaintance of people generally with the theories which had been advanced to explain the phenomenon, and with the work which had already been done upon it. The results of this investigation will be published at an early date. In spite of this great amount of work which has been done, the firefly still preserves its secret of "the cheapest form of light," and seems likely to do so for some time yet.

Although the most common and brilliant manifestations of physiologic light are exhibited by the fireflies, this property is by no means confined to the animal kingdom. Various vegetable forms, from the lowest to the highest, have been reported as producing light. There are many varieties of luminous bacteria and molds, whose activity is seen in the luminous decay of fish and wood. Certain agarics and other of the higher fungi are luminous, and the light given by the underground rhizomorphs of fungus growths is among the first of these phenomena to be reported in scientific literature. Of the higher plants, the marigold, the nasturtium and other garden and wild flowers have been said to emit flashes of light—a circumstance attributed by Phipson to electricity. But, for the most part, the light of vegetable forms seems to be pale and often hard to discern, as compared with the brilliancy and glitter of the firefly and other animal forms.

To those not living on the sea-coast, the most common manifestation of the photogenic function is that produced by some variety of the firefly; but there are a large number of marine forms of varying degrees of organization which possess this property, and some of these are common on certain coasts. For the purpose of discussion, the animal forms will be grouped as marine and land forms.

The simplest marine form which emits light is the "Noctiluca" (*Noctiluca miliaris*), a tiny globule of protoplasm scarcely a millimeter in diameter, which when present—as it usually is—to the extent of millions upon millions, produces the appearance known as the "milky sea" or "phosphorescent sea." Many interesting studies have been made on this little organism, the principal importance of which lies in the fact that it seems to give practically the same reactions as other more highly organized luminous forms. Besides the Noctiluca, certain Beroe and other Ctenophores are often present in immense numbers, and give rise to the same appearance of the milky sea. Higher still, there are a number of Salpæ, and other marine forms which give light, and interesting studies upon them have been made

by Panceri, Quatrefages and other scientific men. But perhaps the most remarkable luminous marine organism is the bivalve, *Pholas dactylus,* known to the French as the "Pholade," and to the Germans as the "Bohrmuschel." This creature has definite luminous organs, whose tissue and secretions are strongly photogenic. It has been the subject of interesting researches by Dubois, and has been shown to react in a manner similar to that of other luminous forms. More recently, certain peculiar organs possessed by deep-sea fish have been determined to be light organs, and thus it appears that in the depths of the sea they need "artificial" light, when the sun's light fails to penetrate, just as on land when the sun is hid.

By far the most brilliant and most commonly known form of physiologic light is that given by the so-called fire-flies; this term embraces a large number of species of insects, mostly Coleoptera (beetles) of two or three genera. Besides these Coleoptera, there are a few luminous forms distributed among the other insects, together with certain myriapods, worms and other occasional forms. In a very few instances luminosity of more highly organized forms has been reported, but for the most part these appear questionable at least. Of the non-coleopterous insects, Diptera (*Chironomus*) and Hemiptera (Fulgoridæ) are said to be luminous; the hills of the South American termites (Neuropteræ) have also been observed to be luminous.

The majority of the insects commonly called fireflies belong to the genus Lampyridæ, including the Italian luciole (*Luciola italica*), the English and continental glow-worm (*Lampyris noctiluca*), the continental firefly (*Lampyris splendidula*), the American fireflies and "lightning-bugs" (*Photinus pyralis, Photuris pennsylvanica,* etc.), and a vast number of other luminous insects. Further south, as in Cuba, Mexico and Brazil, the more brilliant insects belong to the genus Elateridæ, and embrace the cucuyo (*Pyrophorus noctilucus*) and the cucuyana (*Pyrophorus physoderus*). In India there is said to be a luminous buprestid beetle.

Thus it will be seen that, so far from being a rare phenomenon, the emission of physiologic light is one of well-nigh universal distribution, and appears to be an important function in the life of those organisms possessing photogenic activity.

While most of the facts here given apply primarily to the fireflies, they may, in great part, be taken as true for the entire phenomenon of physiologic light. Different forms may show variations in color, intensity and mode of emission of the light, but basically it all seems to revert to the same cause—a cause as yet, however, unknown.

The light given by luminous insects is usually stated by authors to be greenish or yellowish; a few have claimed to observe insects to emit a reddish or bluish light, and marine forms have been reported to emit

a large variety of colors,—red, blue, violet, green, etc.—but the colors are in most cases pale and dim.

Perhaps a dozen investigators have submitted some form of physiologic light to analysis by the spectroscope, and with a few exceptions the results have agreed very well. The best known of these spectroscopic investigations was that of Langley and Very, in 1890. These authors worked with the Cuban cucuyo; briefly, they found that the prism of their spectroscope resolved the light into a narrow band in the yellow and green region of the spectrum, ending somewhat abruptly and showing few red or blue rays; they were unable to find that the light was accompanied by any evolution of heat, such as we ordinarily associate with light produced by combustion or by electric heating, and hence they called the paper presenting their results "The Cheapest Form of Light." This valuable research has recently been confirmed by Drs. Ives and Coblentz, working in the National Bureau of Standards, in Washington, and using more sensitive instruments than were available to Professor Langley and his coworker. Ives and Coblentz found that the light of the common firefly (*Photinus pyralis* K.), was resolved by the spectroscope into "an unsymmetrical, structureless band" in the red, yellow and green, but not extending further than wave length 0.67μ toward the red end of the spectrum, nor than wave length 0.51μ toward the violet end. From the facts at hand it seems extremely unlikely that the spectrum could be discontinuous and renewed in the infra-red or ultra-violet non-visible portions of the solar spectrum.

The remarkable fact which these researches bring out is the extremely high luminous or radiant efficiency of the light. This was estimated by Langley and Very at 100 per cent., and has been shown by Ives and Coblentz to be about 96 per cent. In other words, 96 per cent. of the total energy radiated by the firefly is exclusively illuminating radiation, and does not embrace heat or other subordinate effects. This is the more remarkable when it is considered that the best artificial illuminant has a luminous efficiency of only 4 per cent., and most of them run less than 1 per cent. Of course, this does not mean that the mechanical or chemical processes resulting in the production of the light have an equally high efficiency—that is quite another matter. But it does mean that for a given amount of radiation, the firefly produces the greatest amount of luminous radiation.

But even if we should discover the means by which the firefly produces its light, we should hardly care to use it in our homes. The insect has indeed reached the highest possible radiant efficiency, but it has been accomplished at a sacrifice of color variety that makes the light worse for color effects than even the ghastly green of the mercury vapor arc. Anything not within a very limited range of yellow and green tones would appear black.

The spectrum of the light of some of the organisms which have been reported to give reddish, bluish or other variously colored lights, is said to differ from that of the firefly.

Another very interesting fact brought out by these observers (Ives and Coblentz) is that there may be extracted from the common firefly (*Photinus pyralis* K.) a substance which is fluorescent in certain lights, and that the spectrum of the bluish fluorescent light of this substance is complementary to that of the light emitted by the insect itself —that is, the spectrum of this fluorescent light occupies that portion of the spectrum lying between the green and the violet. The presence of this fluorescent substance may, of course, be merely a coincidence; these same authors found a similar substance in a non-luminous species of the same genus, and various observers have extracted fluorescent substances from different organisms; but if it is a coincidence, it is certainly a remarkable one. Dubois has also discovered a fluorescent substance in the blood of the cucuyo (*Pyrophorus noctilucus*).

Luminous animals and their photogenic tissues are extremely sensitive to irritants, whether mechanical, electrical or chemical; in other words, these tissues are very irritable. Almost any schoolboy is familiar with the fact that pinching a firefly will result in the production of light from its luminous organ. Any other mechanical irritation, such as scratching or pricking with a pin, light taps or blows with a splinter of wood, etc., will produce a similar effect, and this is true not only of the live insect, but also of the luminous organ immediately after removal from the body of the insect; as it dries, however, the luminous organ gradually loses its sensitiveness, and when completely dry it will not respond to mechanical stimuli.

The electric current acts as a stimulus to light production. The passage of the current through the body of a firefly causes it to flash, and sea water containing the *Noctiluca* shows luminous activity during the passage of a current. Light may also act as an irritant or stimulus; Henneguy records that the admission of light to the darkened cabinet wherein were some *Noctiluca* in sea water, caused the evolution of light from these infusoria, and the local firefly has been known to flash following the turning on of an electric light in a darkened room where the insects were confined, the phenomenon being repeated several times.

The most extensive observations upon the irritability of photogenic tissue, however, have been made with chemical substances. These have included a large number of gases and vapors, acids, alkalis and salts, alkaloids, and a vast number of miscellaneous compounds. In general, chemical substances may be divided into three classes with reference to their action upon the photogenic tissue: (1) Those which tend to produce the evolution of light, and which may therefore be classed as

stimulants to light production; examples of this class are mononitrobenzene, carbon disulfide and carbon tetrachloride; (2) those substances which are neutral in their action, neither provoking luminescence nor inhibiting it; examples of this class are hydrogen and nitrogen; (3) substances which poison the tissue and permanently prevent the production of light; examples of this class are bromine, sulfur dioxide and iodine cyanide. Strychnine and other alkaloids cause the production of light, as do also certain poisons; oxygen appears to activate the production of light somewhat.

Probably the most interesting fact so far developed by the chemical study of this phenomenon is that when photogenic tissues have been dried out, the dry tissue glows again when moistened with water in the presence of air. Carradori mentioned this fact in 1808, and quoted Spallanzani and Reaumur as having made the same observation at earlier dates. Carus reported the same observation in 1864, and Dubois confirmed it some twenty years later. Professor Kastle and the writer have been able to perform the same experiment with the American firefly; it is indeed a fact that the photogenic tissue of this insect may be dried, the dry material powdered, and the dry powder kept for some time away from access of moisture, and it will, when moistened in the presence of air or oxygen, glow again; indeed, by careful redrying, the same result may be obtained two or three times on the same specimen of the dry material. Moreover, this dried tissue gives, when moistened, many of the same phenomena with chemical reagents as do the living insect and its freshly detached luminous organ. The property of thus glowing upon moistening after having been dried, does not appear to be confined to the luminous organ of the firefly, but appears to be a constant characteristic of luminous tissue as a class. The main deduction from this fact is that at least three factors are necessary for the production of light by photogenic forms—water, oxygen and some material, as yet unknown, whose oxidation in the presence of water produces light.

Several theories have been advanced from time to time to account for the production of physiologic light. Probably the earliest view was that it was due to the presence of the element phosphorus. That this is not the case is best evidenced by the fact that there are only traces of this element present in the luminous tissues, and that which is present is in the form of phosphates. Yet this is the commonly accepted view of the cause of the phenomenon, and even as recently as 1880, Jousset de Bellesme suggested that the light might be produced by the spontaneous combustion of phosphine. Carradori assumed that the luciole was capable of absorbing from the air or from its food, the " material of light," and of then emanating it again at pleasure.

The fact that the light is unaccompanied by the evolution of meas-

urable amounts of heat certainly shows that if it is indeed a combustion, it is a most remarkable one and one which differs from any analogous process known to us. The view that the light might be the result of oxidation has, however, long been held. Robert Boyle made experiments on this point in 1667, and concluded that the light produced by shining wood and fish was not affected by the absence of air, and was therefore not what we now call a combustion or oxidation. Spallanzani, as the result of his studies on luminous sea forms, came to the opposite conclusion, in which he was opposed by Macartney and Carradori. More recently this phase of the subject has been studied by Dubois, Watasé and Townsend, all of whom have published very interesting observations. As a result of these several observations the conclusion must be drawn that oxygen is essential to the process of the production of physiologic light, and that we have in this phenomenon a true but remarkable form of combustion. Of the mechanism of this process we are still very ignorant. Dubois's theory is that the light is produced as the result of the action of an "oxidase" (oxidizing ferment), to which he has given the name "Luciferase," upon a substance of unknown composition, which he calls "Luciferin," the latter being oxidized by the atmospheric oxygen through the agency of the ferment. It is a little early to accept this hypothesis finally, although it certainly presents some analogy to known processes—for example, the production of the black pigment melanin through the action of the oxidase tyrosinase upon the organic compound tyrosin. Phipson had already described a substance he called "Noctilucin" as the active principle of physiologic light; it seems possible that Phipson isolated and analyzed a culture of photogenic bacteria.

In this connection the structure of the light organs of various animal forms has been given special attention. In general, the results of studies on those forms having special photogenic organs have been essentially similar. Briefly, the luminous organs appear to be masses of cells of some special kind, possibly a fat-derivative, or according to Macaire and Kölliker, an albuminous substance penetrated by a network of trachea (tracheoles), and as the result of some chemical action, apparently oxidation, taking place in these tissues, the light is produced. Whether these tracheoles are in life filled with air or with a liquid seems doubtful; the evidence is contradictory so far as given, but it seems quite probable that they convey air.

What is the purpose of this production of light? Of what value is it to the forms which possess it? This is another side of the "secret of the firefly," which has yet to be solved. Quite probably the function bears some relation to the reproductive life of the insect. The females of the local species (*Photinus pyralis* K.) give a very much less bright light than, and are quite rare as compared with, the males; one female

to from seven to fourteen males seems to be about the proportion. The same condition appears to hold with other species of Lampyridæ also. King states that the female of the Texan form *Pleotomus pallens* is much more luminous, and rather less active than the male. In addition to the photogenic power, the common firefly is possessed of a strong and characteristic odor; Carradori also notes that the Italian luciole has an odor like that of garlic. Many insects indeed possess odors, but that of the Lampyridæ appears to be especially characteristic of the group.

In conclusion, we may say that while a vast amount of work has already been done on this interesting problem, the production of physiologic light still presents many mysteries which science has yet to explain. Nature keeps her secrets well, but this one seems well worthy of solution; the immediate practical and economic importance may not be so great as has been sometimes assumed, but it is a problem of interest alike for the physicist, the chemist, the biologist and the entomologist, and the scientific world awaits its solution with much curiosity.

INSTINCT AND INTELLIGENCE IN BIRDS—III

By Professor FRANCIS H. HERRICK
ADELBERT COLLEGE

I

IN earlier papers we have tried to show how the behavior of wild birds is moulded upon instinct and how some of their instincts have been modified on a large scale, or specialized in a peculiar manner. We shall now examine the other side of the shield, in order to ascertain how intelligently they work, and in relation to their intelligence it will be necessary to consider the growth of the young, and the development of certain instincts, more particularly that of fear.

Many birds, like some mammals, have been lauded by idealists, as paragons of virtue, and endowed with all the human or even angelic powers of intelligence and reason; others, again, have regarded them as the slaves of a blind or stupid instinct, whose lives are stereotyped, and run in grooves, determined largely by heredity. "Do not speak of blind instinct," says Michelet, the historian, "facts demonstrate how that clear-sighted instinct modifies itself according to surrounding conditions; in other words, how that rudimentary reason differs in its nature from the lofty human reason." "Through the thick calcareous shell, where your rude hand perceives nothing," the bird-mother "feels by a delicate tact the mysterious being which she nourishes and forms. . . . She sees it delicate and charming in its soft down of infancy, and she predicts with the vision of hope that it will be vigorous and bold, when, with outspread wings, it shall eye the sun and breast the storm."

While we are not over-zealous in applying the rule of parsimony, like most modern students, we are compelled to take a middle course. When the degrees of intelligence can be more justly weighed, the mental powers of birds, as well as of mammals, will be better understood. At present the balance does not seen to swing very far on the side of intelligence. It is certain that the instincts of birds are modified at every step by association, and that the automatism of habit is quite as striking as that due to heredity, which it sometimes replaces. Many birds learn readily from experience; some remember long, when past experience serves as guide to future conduct. It may well be doubted if they ever attain to the level of analogical reasoning, or of deliberately inventing the means in order to attain a definite aim.

Every observer is no doubt unduly influenced by the force of

isolated facts, and too often falls into temptation by trying to interpret them without a full knowledge of their history. The act in question may appear irretrievably stupid or exceptionally intelligent, while upon fuller knowledge, either view might prove wholly erroneous. Illustrations could be multiplied, but the few which follow, may be of interest.

Shrike Impaling Prey.—The great northern shrike is well known to impale its prey, such as grasshoppers, small birds and rodents, on thorns, and it presumably returns to them when in need of food, although I am not aware that the bird has ever been actually seen in the act of reclaiming its booty. According to some accounts the shrike impales its prey in order to rend it with the greater ease, but still goes on killing after it has satisfied its appetite.

On April 8 of last year I happened to witness a futile attempt at impalement under such favorable conditions of seeing all that transpired, that any mistake as to the meaning of the actions would seem to be impossible. A harsh piercing cry attracted my attention to the bird, which almost at the same moment dived into the stubble of an adjoining field, and came up with a large object in its bill. Fortunately it flew directly towards me, and alighted on the bare, lower branch of a maple tree, less than ten feet from my eye, as if completely preoccupied, and indifferent to observation. I could now see plainly that it held a little shrew, about three and a half inches long, and in a strangle grasp by the nape of the neck, for the body was as limp as a rag. The shrike at once proceeded to walk along the branch and try to impale the rodent, extending its head and drawing the body of the animal in a peculiar manner, against the soft twigs of the tree. It tried the terminal twigs, and the equally soft lateral shoots, and went through the same motions on two different branches. After several minutes of this ineffective effort, with a loud rasping call of a different character, it flew off in the direction of some woods, and was seen to descend to the ground.

The interpretation of such behavior seems obvious—that the shrike, when under the spell of a strong impulse, does not know a thorn-bush from a maple tree. Must it try tree after tree, until one of the right sort is found? If it can return to its tree by memory, why can not it find one suited to its puposes by intelligence; or, was this a bird with inherited instinct to impale, but with no previous experience with thorns?

Robin "Tying Knots."—So far as I have observed, the robin in nest-building, ties no proper knots, unless the present case (Fig. 23) be exceptional, although strings are coiled more or less effectively about adjoining twigs. This nest was placed in a crotch of a pine tree, and one of its supporting branches bore the peculiar double loop or "knot" which is here shown. It seems that a piece of string over two

feet in length was brought to the nest-site, and passed five times round the larger, and twice about the smaller of the two twigs, with overlaps due to working each string-end independently. Having thus fixed it firmly at the middle, the intelligent course would have been to have incorporated the loose ends with the nest. Instead, they were both left flying free, so that this labor, however begun, was not intelligently finished. The eighteen inches of free string really served to render the nest conspicuous.

Woodpecker Drilling for Insects.—While in the Maine woods on August 13, my attention was drawn to the freshly drilled hole of a

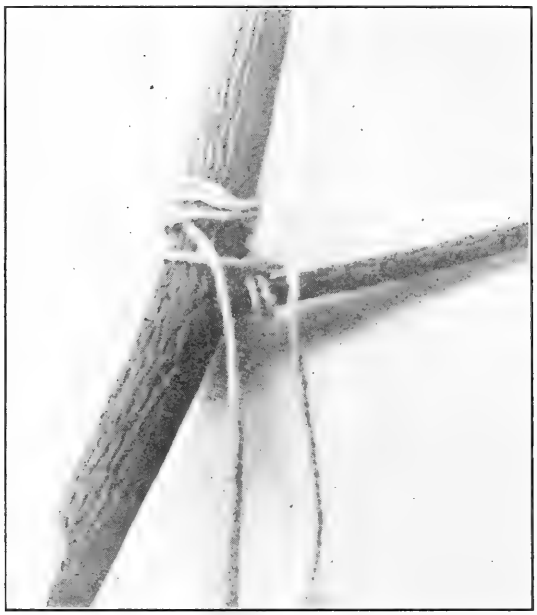

FIG. 23. DOUBLE "LOOP-KNOT" MADE BY ROBIN ABOUT PINE-BRANCH CLOSE TO ITS NEST, illustrating an act probably instinctively begun, but not intelligently finished, since the ends of the twine were not incorporated with the structure, but left hanging free.

woodpecker (Fig. 24), in a pine tree, which was two feet in diameter at the base, and apparently sound. This hole, which was remarkable for its size, had been cut at a point seven feet up, through nearly five inches of solid sap wood, to the heart of the tree, and was 9¾ inches long, 5½ inches wide, and 8 inches deep. These dimensions would imply the removal of over three hundred cubic inches of wood, and the chips, some of which were four inches long (Fig. 25), were plainly the work of our largest northern species, the pileated woodpecker or log cock.

A moment's inspection showed that this woodpecker had tunneled

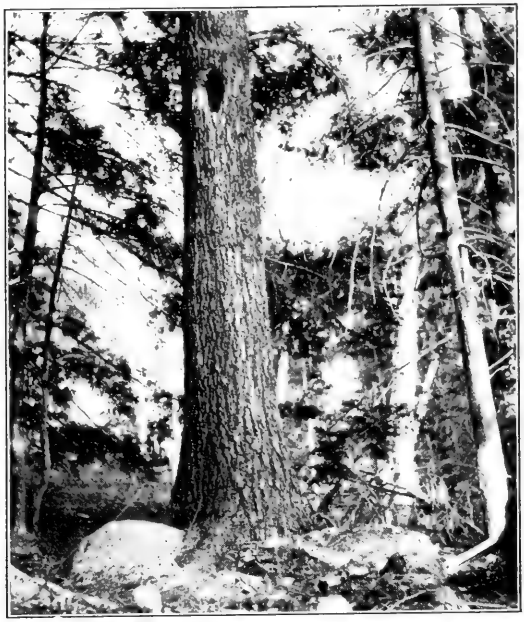

FIG. 24. HUGE BORING OF PILEATED WOODPECKER in a white pine two feet in diameter, to reach galleries of the carpenter ants, seven feet from the ground, where the insect gained entrance; illustrating either instinct to follow sounds, or intelligence in adapting means to end.

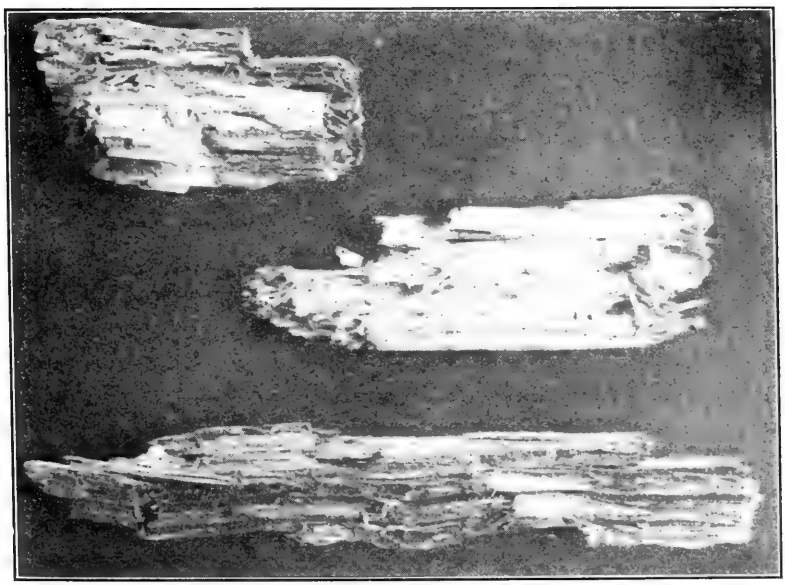

FIG. 25. SOUND PINE CHIPS FROM WORKSHOP OF PILEATED WOODPECKER, shown in Fig 24; some are bent or broken with the wrenching stroke of the bill. Natural size.

to reach the big carpenter ants (*Camponotus herculeanus*), which had extended their galleries up into the tree's heart, and some of which were already entrapped in the exuding pitch. Now one of the chief points of interest in this case was that the ant-borings were few, and the tree itself so large and solid that it would seem to be impossible for any bird to detect their presence by sounding with the bill. On the opposite side at the base, a long ant-hole was plainly seen, and at this point the observations of the woodpecker had evidently begun. A few feet above this opening it had attacked the harder wood in three different places, but desisted after making wells a few inches deep. The woodpecker then went up seven feet, where the wood was presumably softer, and made the drilling, which led to success. With these facts only known, this might appear like a case of reasoning by analogy, but there is still one sense unaccounted for, that of hearing, for the olfactory sense must be ruled out. It is possible, or even highly probable that such birds either instinctively or habitually follow the sounds in wood—sounds of wood-borers at work—and unless it could be shown that the boring of carpenter ants cannot be heard through five inches of solid wood, I should be inclined to accept this view.

This case suggests another practise of woodpeckers, the interpretation of which is clear. The president of a large university recently compared the futile efforts of certain reformers with these of a flicker which was seen to be repeatedly engaged in the vain attempt to "drill a hole through a copper gutter." The comparison may be apt to point a moral, but is a trifle unfair to both the instincts and intelligence of a useful bird, which will drum on any resonator, either to call its mates or for the pleasure of the sound, and by habit will come to the same place daily for more than a week, as in a case which we recently noticed. In this instance the resonant body was the roof of a bird house, one shingle thick, to pierce which, had that been its object, one or two blows of its strong bill would have sufficed.

II. Intelligence in Young Birds

The dawn of intelligence in young birds is seen, as we have earlier shown,[1] through the inhibition of the food-response by association—association with the parent, the nest or the vibration imparted to the tree by the touch of the parental foot.

For the first twenty-four hours, or longer, the altricious nestling behaves like a mechanical toy, and in relation to the food-response is a well-nigh perfect reaction-machine. It responds to every kind of a tactile or auditory stimulus, and within the limits of fatigue its

[1] See also "The Relation of Instinct to Intelligence in Birds," *Science*, N. S., Vol. XXVII., 1908.

responses are about as uniform and predictable as those of an electric bell. Remove the blind and naked cedarbird from its nest, and the complex food-reaction is given as regularly and as continuously as before (Fig. 26). By the second or third day, however, all this has changed, and it is difficult to get any food-response if the bird be out of its nest with which association has become established. If the young are not removed, however, the feeding reaction is usually regularly given, unless checked by satiety or the rise of the instinct of fear. Association in the early life of young birds thus tends, as we have seen,

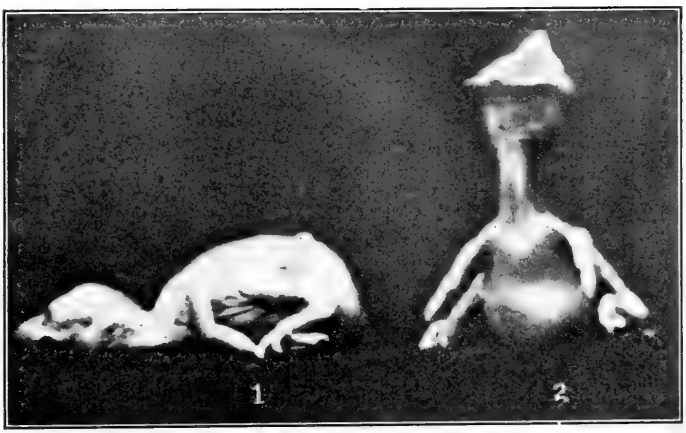

FIG. 26. YOUNG OF CEDAR WAXWING, blind and naked; but little over twenty-four hours old: *a*, typical prone position, when at rest; *b*, typical food-reaction, or reflex response to sound or contact-stimulus.

to cut out a lot of useless reactions, and to limit their responses to those which count.

Growth in Relation to the Development of the Instincts and Intelligence.—We have used the term "instinct" as synonymous with compound reflexes, that is, as reflexes involving relatively complex coordinations of the muscles and other organs. Although the sign or manifestation of an instinct may be suddenly given, the instinct itself, like every other power, seems to be unfolded gradually, and in correlation with the organs upon which its action depends.

In many precocious birds, which run, swim or fly at birth or shortly after, some of the instincts are relatively perfect at the moment of emergence from the shell, or according to certain observers even before this event, as when the young, which remain for hours with the shell chipped, are thought to respond instinctively to the warning cries of their parents. In rare cases, as in certain megapodes, they are born masters of their own destiny, and receive no care from parents which they never see. At the other extreme stand the common altrices, like the robin or cedarbird, which are blind at birth, and so helpless

that they would shortly succumb without that parental care and protection which is so faithfully rendered. Growth and development are continued after hatching, but under new conditions, and at the age of two weeks, when the nest is commonly deserted, the young so far as instincts and intelligence are concerned are at about the same stage as many of the precoces at birth.

Between these extreme types every intermediate stage is found. The American black and yellow-billed cuckoos have a place near the middle of the series, but as we have already seen, they are exceptional in many ways, not alone in the possession of great muscular strength, but in their equally remarkable muscular control, being able to grasp

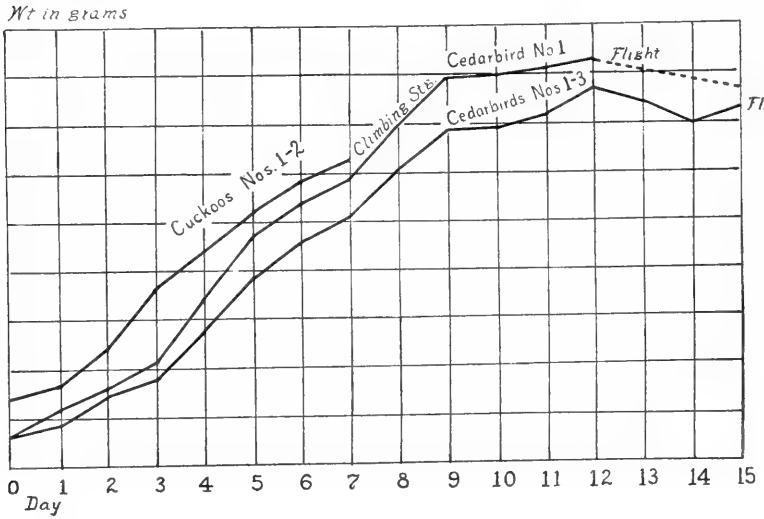

FIG. 27. GROWTH-CURVES OF THE CEDARBIRD AND BLACK-BILLED CUCKOO, as represented by the daily increase in body-weight from hatching to flight from nest, illustrating an initial stage of relatively slow growth (in cedarbird first to third day), a period of maximum increase (third to ninth day), and a final stage of retarded growth or shrinkage in weight. See table.

a twig, and with both feet pull themselves up when but four hours old, or possibly less. This ability is closely related to the climbing stage which is entered on the seventh day, when they leave the nest in succession, and ascend into the branches, where they remain for a period of two weeks before ready for flight.

In the cuckoo the curve of growth, as indicated by body-weight, appears to be quite even and regular after the beginning of the second day (Fig. 27). In these particular birds the highest rate was registered on the third day, and this proceeded without appreciable interruption until the last day in the nest, when it was slightly checked. The power of muscular coordination, association and the instincts of fear and of preening seem to develop gradually after the first day.

Thus the initial attempt to preen, which involves the complicated act of drawing the mandibles over the feather-tubes, may be witnessed on the fifth day; thereafter it is repeated more and more frequently, until on the sixth day it is an established practise, and the movements have become very precise. Gradual also is the development of fear, an early premonition of which is crouching and hugging the floor of the nest, although its final manifestations, such as bristling and spreading, giving a high-pitched alarm, or jumping out of the nest, may seem to mature suddenly, partly no doubt because the stimulus which provokes them is suddenly received.

In the altricious cedarbirds, a single family of which was weighed and measured in 1901, there was (1) an initial period of relatively slow growth, lasting three days, followed by a second period (2) of

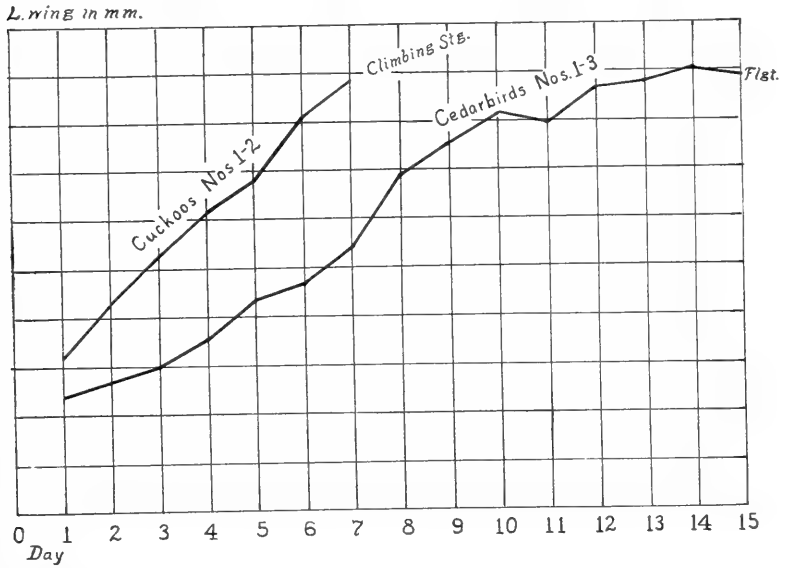

FIG. 28. GROWTH-CURVES OF THE BLACK-BILLED CUCKOO AND CEDARBIRD, based on daily increase in length of wing from hatching to climbing stage or flight. See table.

maximum increase, of six days, and a final interval (3) of fluctuating or retarded growth, extending from three to six days before flight, the birds even losing weight either before or after this event.

The growth-curve of the most vigorous member of this cedarbird family (Fig. 27), the first to hatch and to fly, is seen to start with a higher initial rate, and to maintain it from the third to the ninth day, at the age of flight. Fortunately this bird, which was then lost, was recaptured on the fifteenth day, when it is seen to have shrunk very perceptibly. It had, in fact, lost nearly three grams, or seven per cent., in body-weight. The curves showing the rate of wing-growth in both cuckoo and cedarbird (Fig. 28) follow those of body-weight very closely,

but there is possibly a variation in other organs, such as the leg or tarsus, but it is difficult to obtain reliable measurements on some of these parts. The most vigorous nestling (No. 1) more than doubled in weight on the first day, more than trebled on the second, and more than quadrupled on the third, while on the twelfth day, when it left

FIG. 29. YOUNG CEDARBIRD, No. 1 of table, shortly after hatching, lying on side, cicatrix of umbilicus showing on abdomen; weight 5 grams. August 10, 1901.

the nest it had increased its initial weight seventeen-fold. What ten days will do for the young cedarbird on the score of appearance may be seen by comparing Figs. 29 and 30, the first of which shows nestling No. 1 when about two hours old. The data on which these curves are based are given in the following table.

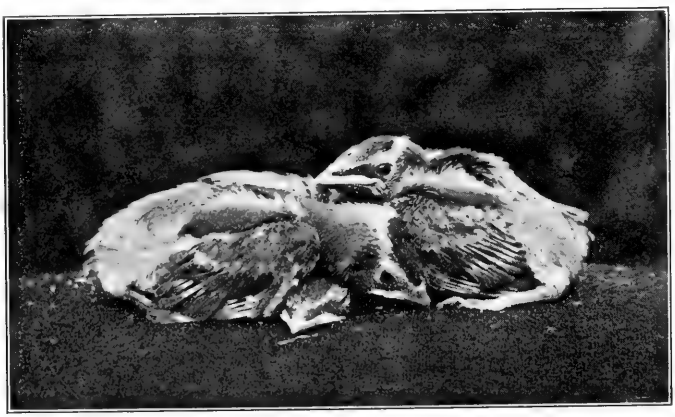

FIG. 30. THE SAME CEDARBIRD (on left) as shown in Fig. 29, ten days later with birds Nos. 2 and 3 from the same nest. All show the crouching tendency, in evidence of fear.

Kuhlmann,[2] who has recently published an interesting study of the development of the instincts and intelligence in certain altricious birds, in particular the turtle dove, the brown thrush and the red-wing blackbird, finds the rate of growth quite similar to that shown for the

[2] *The Psychological Review*, Monograph Series, No. 44, November, 1909.

GROWTH-RECORDS IN CEDARBIRDS AND CUCKOOS, FROM HATCHING TO FLIGHT, OR CLIMBING STAGES

Day.		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cedarbird.																	
Wt. in g.	1	2.41	5.00	7.92	10.44	17.28	23.04	26.64	29.16	34.56	39.24	39.60	40.32	41.04	—	—	38.16
	2	2.41	3.42	6.48	7.92	11.52	17.28	20.16	24.12	28.08	30.90	32.76	33.48	37.44	36.36	34.20	36.72
	3	2.41	3.96	6.66	8.28	12.24	17.64	20.52	21.72	27.72	31.68	33.84	33.12	36.00	37.44	35.28	33.84
	4	2.26	2.52	3.60													
Cuckoo.																	
Wt. in g.	1	—	7.56	11.16	16.20	21.24	25.20	28.16	31.68								
	2	7.02	7.20														
	3	6.66	9.00	12.60	19.80	22.68	26.28	28.08	30.60								
Cedarbird.																	
. wing n mm.	1		12.50	14.00	15.00	19.00	24.00	27.00	29.30	37.00	38.50						
	2		11.00	13.00	15.00	17.00	20.50	23.00	24.80	33.00	38.00						
	3		12.00	13.50	14.00	17.00	20.00	24.00	26.50	33.00	36.50						
	4		10.00	12.00													
Cuckoo.																	
. wing n mm.	1		15	20	25	31	32	38	43								
	2		17														
	3		17	23	28	31	36	43	45								

Cedarbird No. 4 was probably starved by its more vigorous mates, after the second day. Cuckoo No. 2 fell out of its nest. "0" indicates the egg.

cedar waxwing, and has based his results upon a much larger number of cases. He also considers that the three stages enumerated correspond to stages in the development of muscular coordination, of association and the instinct of fear. During the first period, when the power of motor coordination is weak, according to this observer, "the first crude discriminations and associations are made," and the first signs of instinctive fear noted. In the intermediate period (fourth to seventh day), discrimination improves, and association is perfected, while from the beginning of the last period "there is an abrupt change in all the reactions, the food-reaction ceasing for all the artificial stimuli, excepting occasionally for the visual, and fear begins to develop rapidly through several forms of manifestations."

Kuhlmann recognizes five different manifestations of fear, beginning with "cessation of the food-reaction to stimuli that at first aroused it," and ending with "escape from the nest when approached." Discrimination and the formation of associations between the food and certain stimuli are thought to develop simultaneously, and "all stimuli with which no pleasant associations are already formed are then at the same time instinctively feared." The food-reaction is not only modified by association, but is inhibited by fear, and while the development of association is gradual, the passage of one manifestation of fear to the next in order is often very abrupt. Such animals, he says, "come to fear particular things not so much because of unpleasant associations that are connected with them, as because the taming process has not been completed."

We can not accept the conclusion of the writer quoted above, that "fear for particular things remains in the main instinctive." Fear and association, as we have seen, are without doubt developed, like all else, by a gradual process, however abrupt certain reactions of fear may appear. The normal and usual reactions of daily life seem to go through a sifting process; the usual pass readily through the sieve of experience and are stamped as harmless by association, provided they are really harmless, or at least not disagreeable. Further, there seems to be left a residue of strange or unusual sights, sounds or tactual stimuli, ready to produce the fear manifestation, at a moment's call, when this particular stage in the developing instinct has been reached. The reaction is instinctive, but in no true sense would it seem to be the inherited fear of any particular object or thing. Fear of objects having particular, inherent qualities, which are harmful or unpleasant can come only from experience of their harmful or disagreeable effects.

Habits of Young Kingfishers.—In my work on "The Home Life of Wild Birds," I have described some curious habits which kingfishers show when taken from their underground nest at an early age, especially the habit of sitting still, and of walking backwards. The earlier observations were made over ten years ago, and thinking that some other questions might be involved, such as the rising instinct of fear, experiments were repeated on another family of these birds in the summer of 1908. When dug out of the ground on July 8, the five young in this case were found lying twenty-eight inches below the surface, at the end of a six-foot tunnel; they were in "pin-feathers," and according to my estimate about eight days old. Experiments were made on the ninth, fourteenth, twentieth and twenty-third days, when the young were at an age approximately corresponding to the date, with the following results; fear did not seem to play any part as a disturbing or inhibitory factor in their behavior during the first two days; they would go forward or backward, rather indiscriminately, whatever their position might be with reference to the observer, and whatever the nature of the surface upon which they were placed. On subsequent days, the tendency to walk backward increased, and though fear was rising, they were readily quieted, and when placed in certain positions they would sit quiet for long intervals.

The following notes were made on the behavior of these kingfishers on the last day of observation, July 23; when placed on the pine carpet, all began to make off with fluttering wings, going forward with crests erect and rattles sounding. When recovered and placed in line, they soon quieted, and the backward walking movements began (see Figs. 31 and 32). All showed the same tendency, and one, in which it was especially marked, would retreat four feet before the camera could be focused, and this was repeated for the twentieth time. The same per-

formance was given on level ground, or an incline, and whether facing the observer or away from him, though with variable movements in many

FIG. 31. FIVE KINGFISHERS ABOUT TWENTY-THREE DAYS OLD, removed from underground and placed in line, to illustrate habit of keeping still, and of walking backwards.

FIG. 32. THE SAME KINGFISHERS one minute after the position assumed in Fig. 31 was photographed, showing that Nos. 1 and 5 have each taken a few backward steps, while the pose of Nos. 2 to 4 has not appreciably changed.

cases. When placed in head-to-tail line, and in contact, the line would remain unbroken for a surprising length of time, with hardly the turn of a head, which seems to be due to their habit of sitting still, with

wings often interlocked, during their long imprisonment in a dark, subterranean chamber. When, after a good rest in this position, they were brought to right-about-face, two immediately moved backward a few steps, and came to rest again (Figs. 31 and 32). Move around them in circle, and not a head is turned; make a pass of the hand suddenly towards them, and sometimes there is a slight backward movement, but sometimes there is none; reverse again with heads turned away, and two turn part way around, one of which repeats the movement when repeatedly reversed. If placed on their backs, they will slowly right themselves, though if in the nest-hole they were sometimes contented with this position for a longer time.

I am now convinced that the earlier conclusion was correct, and that the peculiar actions described are due to habit, learned underground, and in relation to getting their food, although I was probably in error in supposing that their instinct of fear was ordinarily delayed until they were ready to leave the tunnel. When such birds are handled daily there can be little doubt that this instinct is liable to be checked. The arched chamber of sand in which these kingfishers lay was 11½ inches in diameter, and 6½ inches high, while the tunnel leading to it had a 3-inch bore. Its temperature stood at 77° F., and was seven degrees cooler than that of the air outside. Since these five birds were each about six inches long it is evident that they were closely packed, and that once in the tunnel, no turning movement would be possible, any more than for the adult which after feeding always backs out of the hole. Now we have earlier noticed a tendency among the older young to crawl down the passageway, and meet the parent at the mouth, but that they are hustled back and presumably fed at the nest, hence the probable association between walking backwards and getting food, and hence the curious habit displayed by these birds when they are taken from the ground.

III. Intelligence in Adult Birds

There seems to be little intelligence displayed by birds in regard to the quantity of food served at the nest. What one of the altricious kinds really does in effect is to "test" the reaction of the throat of its nestling, and to await the response. If this is not forthcoming the food is quickly withdrawn, and another is tried. The most responsive bird gets the food, and there is no distribution on any other basis than this. The same bird may thus be fed twice or even three times in succession, the strongest usually getting the most, and the amount which it can take being reflexly determined by the gullet.

On the other hand, intelligence is certainly shown in the kind of food served, and in the treatment which it often receives. Thus a gull

chick when but a half-hour old gets only small bits of predigested fish, but at the age of three weeks it may be invited to bolt an entire squid. Again a bird like the black-billed cuckoo, which has repeatedly tried to serve a large insect and failed, has been seen to quickly withdraw it, mince it fine with her bill, and then offer it with success.

Birds quickly acquire a habit of going to their nest, by a definite path, through association, and if the branch which holds it is suddenly removed, they try to follow the established course, and will hover at the point in space which the nest formerly occupied, even when their young are in full sight, and these actions may be repeated many times, until the old habit is broken by an actual visit to the new position (compare

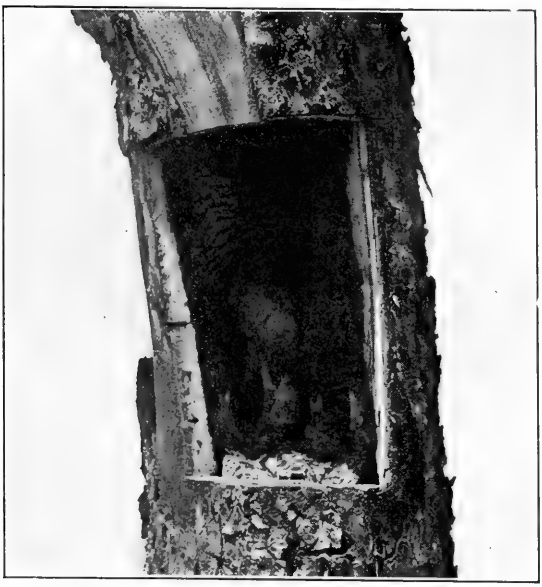

FIG. 33. FLICKER FEEDING YOUNG, with nest-hole opened at the back, illustrating the force of old habit. The bird for some time continued to enter the hole by the usual course.

Figs. 33 and 34). The habit of entering the nest from a certain side, of facing the same way while sitting over the eggs, of grasping the same branch when inspecting and cleaning the nest, and of leaving it in a definite manner, are all more or less fixed by habit in a brief course of time. In the same way drinking and bathing places, perches, spots for dusting, sun-bathing and sleeping are resorted to by habit for longer or shorter periods, according to the other conditions which modify behavior.

Do birds discriminate their own eggs and proper young? Very many do not, yet some do, sooner or later. The success of the European

cuckoo and the American cowbird, the young of which are reared by foster-parents of many diverse species, would argue for little power in this direction. Yet, in some cases, the foreign body is promptly removed, when the nest is not summarily deserted through fear.

The freedom with which certain finches and grosbeaks learn to imitate difficult notes, and the fair degree of precision with which some

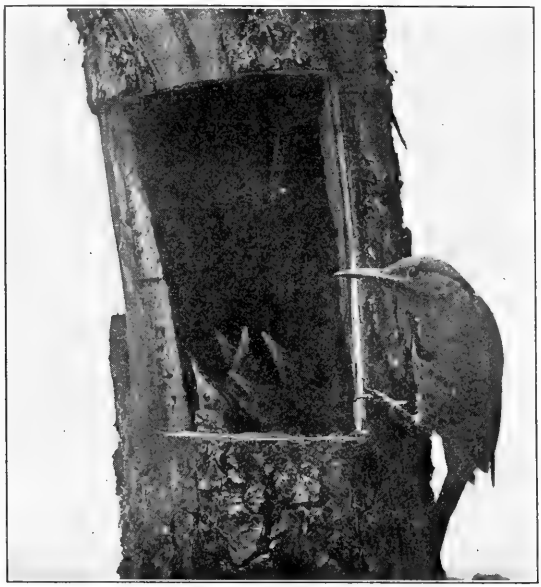

FIG. 34. THE SAME FLICKER as shown in Fig. 33, after new habit of entering opened nest was formed.

of the parrots, crows, jays, jackdaws and magpies reproduce spoken words, or even short sentences, show that they readily discriminate differences in the pitch of sounds, although they do not possess a cochlea of the complexity of structure found in mammals, and it is the cochlea in which this power is supposed to reside in man. It is interesting to note that the magpie, though a star performer in this art, never exhibits it, according to Blackwall, in a state of nature.

The bower birds of Australia show a decided liking for bright and colored objects of various kinds, which they work into their remarkable "runs," bowers, or "play-houses," and the crow, and other members of his tribe, which are commonly regarded as the most intelligent of birds, can seldom be trusted in the presence of any small and shining objects whatsoever, which they will steal, and either carry off and hide, or work into their nests. To mention a trivial case—a tame young crow once entered my room, made off with some objects on the dressing table, and deposited them on a belfry-roof hard by. Again, the hooded

crow in Egypt and India, where from a long and undisturbed intercourse with man, it has come to build its nests in the city streets, and in Cairo even before the foliage of the lebbek trees is out, often gives free rein to this propensity, as was well shown by the experience of an optician in Bombay, who lost a large store of steel spectacle-frames, and later found them in a ruined state, worked into a nest of this familiar bird. The propensity to seize bright objects, and to hide and store food by burying it in the ground, a practise attributed to the European crow, raven, magpie and rook, is undoubtedly instinctive in origin. Their ability to find it again would depend more upon intelligence than in the dog, which has the same tendency, for they are presumably without the guiding power of scent. The Californian woodpecker (*Melanerpes formicivorus*) is noted for the autumnal stores of acorns which it embeds in the bark of trees, but the strong instinctive impulse which shapes its conduct is accentuated by the reported fact that the holes so nicely drilled are occasionally filled up with stones.

That color plays an important part in the lives of birds seems highly improbable, although it is a commonplace fact that the nest in many cases harmonizes perfectly with its surroundings. For several seasons I made a practise of offering colored yarns, such as blue, brown, green and bright red, to various species of birds, for building purposes, and especially to robins and cedar waxwings; as a rule, all colors were taken indiscriminately, with very bizarre nests as a result. When white threads or long streamers of cotton cloth were added, these were usually taken first, and in greater quantity, apparently because they were more conspicuous, and sometimes to the detriment of the builders. Thus, one of the least flycatchers took and dropped so much of the cloth that a white trail was finally laid from field to nest, in the construction of which five times more was used than needed. The quaint structure which resulted was too obvious to escape destruction, and it did not endure many hours.

The docility of birds is well illustrated by the trainer's power over many species, and by the tricks which, through a system of rewards and punishments, they can be made to perform. A classical illustration is furnished by the art of falconry, the popular sport of middle-age Europe, in which the young of the wild peregrine falcon, or of some other hawk, was trained to limit its instinct to kill to a particular kind of game, to follow the falconer afield, to stoop to the quarry, and return to its master's call. After a similar fashion the instincts of the cormorant have been molded to the will of man, and successfully used in taking fish, a practise which I am informed may still be witnessed in certain remote fishing communities in Japan, the trained birds descending from father to son.

Modern experiments in the laboratory, which have been conducted

by students in recent years, by the Hampton Court maze or labyrinth method, upon young chicks, and various wild species, show an ability to learn more or less rapidly, according to the simplicity of the path to be traversed. They always seem to be guided in large measure by sight. Their educability has been further tested by Thorndike and others, by placing food within sight, but enclosed in a wire box, access to which can be reached only by working some simple contrivance, with bill or foot, such as pecking or pulling at a string. The animal is thus induced to do an unusual thing, or to do it in an unusual way, but some species, like the house sparrow, have proved apt to learn, and though success may come first through accident, by the tenth or some later trial, the new act is learned, and unnecessary movements are in time eliminated. The effect of the acts performed, as in the case of exit from the labyrinth, is remembered for days or weeks, according to the strength of the habit, or the ability of the learner. Whether the memory involved in these and similar acts is of a visualized character, involving a memory idea, image or picture, may be doubted, though Edinger among others is not inclined to admit this. We might ask why a bird, with a memory image of the position of her nest, does not always strike a direct path to it, after reaching her tree. Why should she slavishly follow the track stamped in by previous associations, walking along a certain branch, and grasping a certain twig, before landing at the nest-side, a practise very commonly followed? Such behavior certainly can not always be attributed to the inhibitory effect of fear.

All the intelligence which birds may on occasion exhibit seems to give way under the spell of any of the stronger instincts, as when the male canary, as related by Blackwell, plucked the feathers from the necks and backs of its own young in order to line a newly built nest, although other feathers were supplied to it in abundance. They seldom meet emergencies by doing the intelligent act, and, in spite of the anecdotes, probably but seldom come to the effective aid of their companions when in distress. On the other hand, I have more than once seen a mother bird try to pluck a hair or piece of grass from the mouth of a nestling.

It has been asserted that only birds can be frightened from fields by scarecrows, but to most birds any strange object is a "scarecrow," which may in time, and often brief at that, become familiar through association, as shown by the many devices used by farmers to frighten crows from their fields of newly planted corn. The genuine scare *crow* is a subject worthy of further study.

At this point I wish to notice certain anomalous actions of peculiar interest in birds, and to refer particularly to the wood swallows (Artamidæ) of Australia, the hornbills (Bucerotidæ), of the East Indies, and to the honey-guides (Indicatorinæ), of the East Indies and Africa.

The wood swallows are social, gregarious birds of rather small size, characteristic of the tropical forests, where they feed upon insects, and often "hawk" them, like the swallows and swifts. Many have the curious habit of "swarming," or clustering in cold or wet weather in sheltered places or under trees, possibly for the purpose of keeping warm, though this appears to be an assumption; when thus bunched, they crowd one upon another, all heads up, thus forming a great ball-like mass several feet in diameter; if disturbed they go off with startling effects produced by the whirring of many wings, often leaving, it is said, a few dead ones behind, which might have been smothered in the press. All this is suggestive of rheotropism, or the tendency shown by many fish, insects and other invertebrates to orient themselves in response to currents of air or water, and in particular of the clustering tendency shown by the young of many aquatic animals, as well as by many flying insects. Whatever its history may prove to be, no one can doubt that the act is purely instinctive in origin. We are reminded of the swarming habits of chimney swifts, which have been known to enter hollow trees in great numbers for the purpose of roosting and passing the night, especially after their arrival in spring and before their fall departure.

Hornbills are large birds of peculiar structure, and wide distribution in the old world, being noted for their great serrated bills, which in many of the species are surmounted by a remarkable casque or helmet. But it is in the cyclical instincts of their reproductive period that we find the most extraordinary departure from the common type. Before she is ready to lay her eggs, the female hornbill enters some suitable cavity, in a dead tree or branch, and with or without the assistance of the male, proceeds to wall herself in, closing the opening with mud or excreta, or with both, with the exception of a hole large enough to admit the bill, and the food which is passed in by the male. While thus confined, the female lays the eggs, incubates them, and through the cooperation of her mate their naked and helpless young are reared until ready for flight; then the prison-house is suddenly burst open, the enfeebled mother and the young are liberated, and the happy family united in the bright world outside. Further, at intervals during this period the male casts off and regurgitates an inner layer of the gizzard, which with all the contained food comes up like a dumpling, that is to say, a package or thin-walled sac, three inches long by two inches in diameter, and upon this generous food-supply the female is able to subsist for some little time.

The practise of closing the opening to the nest is to be regarded as a modification of the nest-building instinct, and while its history has no doubt been lost in the remote past, it may be compared with a not wholly dissimilar practise of the European nuthatch, which also nests

in natural cavities, and when the entrance is large regularly blocks the passage with mud until it will barely admit her body. The hornbills have possibly lost the cleaning instinct, if they were ever possessed of it, and the singularity of their present activities must be attributed to instinct alone.

The little honey-guides are related to the barbets, and hoopoes, rather than to cuckoos, although like many of the latter they are thought to regularly steal the nests of other birds, and never rear their proper young. But aside from this diversion, they are said to conduct the passing traveler to bees' nests, to call his attention to the important business in hand by hisses and shrill cries, and to even fly in his face "as if enraged at not being followed." That such efforts are not wholly altruistic may be gathered from the fact that they will eat the bees, grubs and honey alike. According to the accounts, the honey-guides are the "pointers" among birds, for when the woodsman is encountered, they flutter up to him and point the way to a nest, and if followed, go on and on, but halt when hot on the trail. They will also point to empty nests, or even to a domestic hive, but more significant than this, they will follow a dog, or lead the confiding traveler to a leopard, cat or snake, showing clearly that, whatever the origin of this practise, whether concerned with the instinct to sound the alarm at a common enemy, and to follow it and keep it in view, or not, we are dealing with an instinct; and probably one of very pure type.

We will close this account by giving one or two reputed instances of bird-intelligence which stand out in a marked degree from others of their kind, on account both of the acts themselves and the credibility of the witnesses. Thus Montagu, whose excellence as an observer is abundantly proved in his "Ornithological Dictionary of British Birds," states that he once saw two crows (*Corvus corone*), by the seashore "busy in removing small fish beyond the flux of the flowing tide, and depositing them just above high-water mark, under the broken rocks, after having satisfied the calls of hunger." It seems to me that too much has been made of this instance, since it may with equal justice be interpreted as an illustration of the instinct to hide, the circumstance of the tide being fortuitous, for it does not follow that these birds knew that the tide would surely advance and sweep away their prize. The incident, however, is interesting in relation to another, told of the hooded crow (*Corvus splendens*), by the worthy Blackwall, who saw these birds "on the eastern coast of Ireland, after many unavailing efforts to break with their beaks some of the mussels on which they were feeding, fly with them to a great height in the air, and, by letting them fall on the stony beach, fracture their shells, and thus get possession of the contents." Perhaps it would not be easy, says Blackwall, "to select a more striking example of intelligence among the feathered

tribes than this, where, on one expedient proving unsuccessful, after a sufficient trial had been made of it, another was immediately resorted to."

A similar habit has been attributed to the gull, but with how much truth I am unable to say; the exact history of its origin, in either case, would be of much interest. It would seem to have arisen either from accident or from ideas, for the question of imitation can here be ruled out, so far as the initial performance in a given individual is concerned. The very rarity of the habit, attested by the fact that it has been so seldom reported, seems to clearly point to an accidental origin, and to the conclusion that it does not rise above the level of associative memory.

THE PALEONTOLOGIC RECORD. III

ANATOMY AND PHYSIOLOGY IN INVERTEBRATE EXTINCT ORGANISMS

By RUDOLF RUEDEMANN

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THE inquiry into the position of anatomy and physiology in invertebrate paleontology seems very appropriate at present, since paleontology is steadily becoming more closely affiliated to zoology, and the sphere of zoology is at present dominated by comparative anatomy and physiology.

Since, however, invertebrate paleontology has only the hard parts, mostly outer shells, at its disposal, the view still prevailing among zoologists that little is to be expected from it in regard to the solution of the problems of anatomy and physiology of the lower animals seems natural. Nevertheless, the results already attained prove that if paleontologists do not approach their material with a geological knowledge only, as has been done in the past altogether too often, most gratifying results may be obtained, at least in some classes, for it must be conceded that the connection of the hard parts with the fleshy parts is very unlike in different classes; it is very intimate in some, as the crinoids and brachiopods, and again more indifferent, as in the gastropods.

But it is not claiming too much for invertebrate paleontology if we say that where the hard parts are of great structural importance, paleontology has earlier taken cognizance of this fact and consequently gone ahead of zoology. As an instance I may cite Zittel's investigations of the skeleton of the hexactinellid sponges which have taught the fundamental importance of the form of the spicules and the structure of the skeleton in that class and whose results have been readily adopted by zoologists. In classes which, as the brachiopods and crinoids, are to-day mere shadows of their former greatness, paleontology has its greatest chance, and it would fail in its task if it would there not become the instructor of the affiliated science; and it is gratifying to see that this fact is finding recognition, as, for instance, in Ray Lankester's "Treatise of Zoology," where the chapter on the crinoids has been entrusted to Bather, a paleontologist and one of the best authorities on crinoids.

It is apparent that in such classes as those just mentioned, of which only the last ends of the branches are still alive, the origin and nature

of many structures can not be elucidated, even by the embryology and comparative anatomy of the recent forms, but only by paleontology. Such a structure is, for instance, the mystifying stem of the crinoids which, by a study of the primitive ancestors of the crinoids among the cystids, is readily recognized as a dorsal evagination of the body. Likewise, to cite another example, the siphuncle of the recent *Nautilus,* which is obscure as a wholly rudimentary organ, is in such primitive Paleozoic cephalopods as *Nanno* and *Piloceras,* still seen in its original form and thereby recognized in its nature.

Since that which has already been accomplished in fossil anatomy is proof that there are still larger fields to be ploughed and harvested, it is proper to inquire into the best methods of this work before us.

We first need more extensive and more intensive or more detailed purely descriptive anatomical researches of the invertebrate fossils. There are many species that, when investigated in their smallest detail, are bound to give important results. I may cite here, as examples of such accomplishments, Hudson's minute study of the strange *Blastoidocrinus* of our Chazy rocks with its 90,000 ossicles, or that of the *Eurypterus fischeri* by Holm. Of this archaic fossil marine arachnoid, a relative of the scorpion and of the king crab, it can be fairly said that, as far as its chitinous integument is concerned, it is as well known as any recent species. We know, through Holm, its gills, its complex genital appendages of both sexes, and even its fine hairs and bristles. Dr. Clarke and myself have lately continued these investigations in the American eurypterids, and there observed the structure of the compound eyes, the pore system of the segments, the genital apertures, the mode of moulting, the arrangement of some of the principal muscles and other anatomical facts of interest.

It can be said that this field of detailed descriptive anatomy has been merely touched thus far, as far as our fossil invertebrates are concerned, and altogether too much neglected. This is not only true as to the gross anatomy, but still more so as to the microscopic structure. It must be conceded that owing to the secondary changes in the rocks, this latter line of investigation meets with great obstacles not fully appreciated by the zoologist, and that it is only in its infantile stage in some classes. But the results obtained by the microscopic research of the Paleozoic bryozoans in this country may be considered as a striking example of what persistency and enthusiasm may still accomplish. In microscopic anatomy of the fossils the training of a geologist is as much required as that of a zoologist and the history of these investigations shows that a zoologist without geologic training may be badly misled by the deceptive states of preservation of the fossils.

The main object of anatomical research is to result in comparative anatomy and to determine what parts are fundamental or primary and

what have undergone modifications due to functional changes. It is obvious that here invertebrate paleontology is in a position to answer a host of questions that could not be successfully approached by comparative anatomy of recent forms, by the direct observation of successive changes. Its methods of investigation have already been applied with wonderful success to large parts of our Paleozoic crinoids, brachiopods, bryozoans and cephalopods. And I do not doubt that the time has come when the preliminary stage of mere description of fossils is passed, and a monographic treatment of each class that would fully enter into the comparative anatomy of all structures preserved, could be profitably undertaken.

It is only by this work that paleontology can hope to make those contributions to philosophical anatomy in revealing the causes of the different structures which it is especially fitted and called upon to furnish by its ability to study the gradual development of the structures. Wherever a class of fossils has been thus thoroughly treated, it has given a fruitful crop of new hypotheses and principles, as is instanced by Hyatt's investigation of the fossil cephalopods. Most classes, and especially the corals, echinoids and trilobites, await such treatment by competent investigators.

Since physiology is that branch of biology that treats of the laws of phenomena of living organisms, it might seem hopeless to expect any information from the fossil world. This is apparently the more true in regard to the invertebrates, since a special physiology exists thus far only for men and the higher invertebrates and the recent invertebrates are largely a virgin field. For this reason also, only the most general foundations of comparative physiology have been laid, and an invertebrate fossil physiology would get as yet but little support from that side. Moreover, the main source of exact information in recent physiology is the experimental method, and this is wholly inapplicable to the fossil world.

And yet it seems to us that the empiric method upon which physiology has so long flourished promises also rich fruit in paleontology. I can do no more now than briefly mention the problems that most readily suggest themselves here. Invertebrate paleontology will be especially competent to furnish contributions to the mechanics of physiology by throwing light on the development of the means and modes of locomotion. In connection with this problem invertebrate paleontology also shows most clearly the deep-reaching influence of secondary fixation on the structure of the organism, as in the case of the strange *Richthofenia* among the brachiopods and the Rudistæ among the lamellibranchs. It can not fail that the progress in recent invertebrate physiology will stimulate inquiry into the physiology of the fossils; and further that, as invertebrate fossil anatomy progresses, the data for such inquiry will also come forth.

Another problem closely connected with that of the mode of locomotion is that of the origin of the organs of sense, and also upon this, as far as the organs of seeing at least are concerned, the fossil invertebrates are able to throw some light, as in the trilobites and eurypterids.

Another line of inquiry is that of the mode of nutrition as recognizable by the appendages, and its influence upon the general structure. Under this heading such interesting minor problems as that of the origin of parasitism arise and may be solved, as indicated by a recent publication as to the time of beginning, causes and gradual changes of parasitism, to its very complex present conditions.

Probably also the physiology of respiration will in time receive important additions as far as the echinoderms, crustaceans, scorpions and eurypterids are concerned.

The widest scope, however, will have those problems that are connected with the reactions of the organisms to their physical and chemical surroundings. The invertebrate paleontologist meets forever, in sight of the ever-changing faunules, the question, what exterior influences caused these changes? Often they can be directly recognized, as in the dwarfed faunules of the Devonic pyritiferous Tully limestone or of the bituminous Marcellus and Genesee shales or the eurypterid faunas of the Salina lagoons. The systematic investigation of these reactions through the series of formations is an inviting task.

A special problem of singular interest connected with the reaction of the organisms to the chemical surroundings is that of the composition of the shell of the invertebrates. There is good evidence for the view that the shells were at first chitinous and that but gradually they became calcareous or siliceous. This important question again is intimately connected with that of the original composition of the ocean, and this line of inquiry again leads us to the highly fascinating paleophysiological problem, lately so happily dealt with by Professor Lane, as to the geological evidence on the original composition and origin of the vital liquid, the original body temperature and the physiological origin of the hard parts of the invertebrates in general.

CONTRIBUTIONS TO MORPHOLOGY FROM PALEONTOLOGY

By Professor WILLIAM BULLOCK CLARK
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OUR knowledge of the morphology both of the animal and plant kingdoms has been largely extended by the work of the paleontologist. Mention needs only to be made of the many species, genera and families, even orders and classes, established solely for fossil forms

to show how much we owe to paleontology. There is not a single subkingdom but has been immensely enriched from this source.

Some of the fossil species possess morphological characters so closely allied, on the one hand to earlier, and on the other to later, forms as to indicate that they occupy a position in the line of descent, and phylogenetic series have been established frequently on this basis. As examples we have the well-known developmental series of the horse and the camel. Other illustrations may be found in the *Paludinas* of the Slavonian Pliocene and in the *Planorbis* types of Steinheim.

Still other fossil forms combine in the same species several morphological features which later become segregated and characterize different types. Such "synthetic types" serve to show the common origin of the forms in question if not their actual ancestors and have greatly enlarged our knowledge of the morphology of the several groups involved. These early forms are, for the most part, highly generalized, while their descendents are variously specialized. Take, for example, the mammalian *Condylartha,* small, generalized Ungulata with an astragalus shaped almost as in the Carnivora; or the reptilian *Anomodontia* with intermediate skeletal characters between the highest labyrinthodonts and the lowest mammals; or again, the early Paleozoic cystoids with generalized characters in their calyx plates which appear in more specialized forms in later crinoids and blastoids. An almost indefinite number of such illustrations might be cited.

Still other fossil forms present morphological characters so different from other fossil or living species that the genetic relationships may not be determined accurately. Some of these are possible of reference to already defined orders, while others present so many diverse morphological characters as to require the establishment of new divisions for their reception.

A survey of the known fossil and living forms shows that not only have old species constantly become extinct during the progress of geological time, but new species have been as frequently appearing. This is equally true of genera, families, orders or even classes. Some forms have appeared and disappeared, as the case may be, suddenly; others slowly. The great group of the Ammonites, for example, disappeared suddenly at the close of the Cretaceous after showing many degenerate characters, while the Trilobites gradually declined during late Paleozoic time before their final extinction. One of the most striking features in the developmental history of plants and animals is found in the great number of fossil types which have left no descendants.

Both the animal and plant kingdoms furnish a wealth of material with which to demonstrate the aid which paleontology has rendered to morphology.

The contributions of invertebrate paleontology are numerous and striking:

The *Protozoa* afford in the Carboniferous Fusulinidæ and in the Tertiary Nummulinidæ forms with very different morphological characters from those living to-day, while the numerous extinct species of the Lituolidæ and Textularidæ in the Cretaceous and of the Miliolidæ and Globigerinidæ in the Tertiary have greatly widened our knowledge of the entire subkingdom.

The *Cœlenterata* in the Paleozoic Tabulata and Graptoloidea show types so different from living forms that the systematist has never been able to satisfactorily assign them to a position within the limits of the phylum. Many external and internal characters appear that are quite unknown in later forms. On the other hand, the paleontological subclass of the Tetracoralla long imperfectly understood is now regarded with a fuller knowledge of the morphology as affording the probable ancestors of the later Hexacoralla.

The *Echinodermata* have furnished two classes, the Cystoidea and the Blastoidea, unknown after the Paleozoic, whose morphology aids very materially in an interpretation of later and more highly differentiated forms among the Pelmatozoa. Thus the cystoids, which have been regarded as the ancestral type from which the crinoids have sprung, afford forms like the Camarocystites, in which the arms are similar to those of the crinoids although the calyx plates are irregularly arranged and thus cystoidean in character. Both the Asterozoa and Echinozoa are represented in the fossil state by many species that greatly widen our knowledge of the morphology of this group. Take for example, the Echinocystites, regarded as belonging to the Palechinodea which has a valvular pyramid of calcareous anal plates so highly characteristic of the cystoids.

The *Molluscoidea,* to which phylum belong the Bryozoa and Brachiopoda, would be but imperfectly understood from a morphological standpoint but for the vast number of fossil forms. The Brachiopoda have been estimated to have less than 150 living species, while probably more than 6,000 fossil species have been described. Of the 31 families only 7 have living representatives. We are dependent, therefore, largely on the fossil forms for our knowledge of the morphology of this class.

The *Mollusca* with their varied forms, although so well represented to-day, have furnished in the fossil state one of the most interesting and important orders in the animal kingdom, the Ammonoidea with its 5,000 and more species ranging from the Devonian to the Cretaceous. Even the allied Nautiloidea, although containing living forms, attained its chief development in the Paleozoic, and it is from these ancient forms that we obtain our chief knowledge of the morphology of this group with their early straight and irregularly coiled types.

The *Arthropoda* afford in the Paleozoic the important groups of the trilobites and euripterids, forms that have aided greatly in the inter-

pretation of the entire phylum. The trilobites from their morphological features have been generally regarded as entomostracous crustaceans with relationships on the one hand to the Phyllopoda and on the other to the Merostomata, while the coalescing of the caudal segments suggests also a relationship to the Isopoda.

Vertebrate paleontology has also furnished much to morphology.

The *Fishes* would be but imperfectly known in their wonderful variety but for the fossil types. The problematical group Agnatha found only in the Silurian and Devonian affords no certain evidence of a lower jaw or paired limbs, and in some of the genera of the Ostracoderma mimic in a curious way the contemporaneous euripterids, which has led some to erroneously ally them with the Merostomata. The dermal armor of most of these forms is also a striking morphological feature.

Woodward divides the fishes proper into Elasmobranchii, Holocephali, Dipnoi and Teleostomi, and considers that the common ancestors of all were Elasmobranchs. Numerous fossil forms among the Elasmobranchs and Dipnoids as well as the Crossopterygians which have been thought by many to bridge the gap between the Telelostomi and Dipnoi have added largely to our knowledge of the phylum.

The *Batrachians* which consist to-day largely of diminutive forms were represented in the later Paleozoic and early Mesozoic by the Stegocephalia which contain the giant labyrinthodonts with their highly complex infolding of the walls of the teeth.

The *Reptilians* which began their existence toward the close of the Paleozoic became so numerous and diversified during the Mesozoic that this division of geological time has been referred to as the age of reptiles. Several orders of Saurians containing many giant types flourished during this time, but became practically extinct before the close of the period. With the adaptation of some for walking on their hind legs, of others for swimming, and still others for flight we have developed a great variety of morphological features that would never have been suspected from a study of living forms.

The *Birds* which are recognized as possessing certain dinosaurian relationships and were doubtless derived from one of the reptilian orders are unknown prior to the Jurassic. The Mesozoic forms are generalized, the tail at first not being atrophied and the pelvis imperfectly developed as in later forms. The vertebræ also had not acquired their saddle-shaped articulation while teeth were present in the jaws of the adults. Such forms certainly add greatly to our knowledge of the morphology of this class.

The *Mammals* which began in the early Mesozoic were represented throughout the Cenozoic time by highly diversified forms, many of which have left no descendants. The gradual evolution of the mam-

malian skeleton has brought about many morphological modifications from those shown in the Batrachia and Reptilia. We find the skull loses the prefrontal and postfrontal bones, the mandible is simplified, the limb bones show a development of terminal epiphyses with ossification to the center of the vertebræ and the bones of the pelvic arch are ossified. From the beginning of the Tertiary time a marvelous variety of morphological characters appears, and without the fossil types we should have but an inadequate conception of this great phylum.

The contributions of paleobotany to morphology are in some respects quite as striking as those of paleozoology.

The fossil *Thallophytes* have not furnished any very striking variations from their present morphological features, while the *Bryophytes* are scarcely represented as fossils except in very recent deposits.

The remaining phyla, the *Pteridospermatophytes,* the *Pteridophytes* and the *Spermatophytes* have their oldest known beginnings as far back as the Devonian and their study has enormously widened the bounds of plant morphology.

The *Pteridospermatophytes,* which are confined to the Paleozoic, are in habit and vegetative morphology ferns—in methods of reproduction and in the morphology of their reproductive organs typical seed plants. They alter our whole conception of ferns and seed plants and in their significance are comparable to archetypal vertebrata, the acquisition of the seed habit in plants and the vertebral column in animals probably marking the culmination of the transfer of vital activity from aquatic to terrestrial conditions.

In the *Pteridophytes* the extinct Paleozoic class, the Sphenophyllales, is significant, since the morphology of the distinct lycopod and *Equisetum* lines seems to merge in this group. The lycopod type, itself represented in the existing flora by six or seven genera of herbaceous plants, monotonously uniform in their morphology, is found in the Paleozoic to constitute one of the chief units in the arborescent flora with numerous species of complex organization, whose stem, foliar and reproductive morphology was quite unknown to botanists (*Lepidodendron, Sigillaria,* etc.). The *Equisetum* type furnishes a like case. With few existing species of minor importance and uniform morphology we find in the Paleozoic a host of forms, many of them arborescent and of varied and complex structure (*Calamites, Archæocalamites,* etc.). Similar examples could be drawn from the fossil representatives of the true ferns.

In the *Spermatophytes* another wholly extinct class, the Cordaitales, embraces a curiously organized group of conifers extending back to the oldest horizons from which land plants are found, and continuing to the close of the Paleozoic as one of the most abundant as well as the highest type of pre-Mesozoic plant. In the older Mesozoic we find two

groups of plants which have made similar great contributions to morphology. The Cycadales or cycad-like plants, which to-day are an inconspicuous group, were one of the dominant Mesozoic types, and any understanding of the modern forms rests entirely upon a study of their immensely abundant Mesozoic ancestors. The other group, the Ginkgoales, represented in the existing flora by a single species, the ginkgo, is found in the Mesozoic to have been represented by many genera and species of great diversity.

The dominant plants of to-day, the conifers on the one hand, and the angiosperms on the other, have each afforded many extinct genera, the former with more fossil than recent species, and only understandable in the light of their fossil ancestors. Vegetable morphology based only upon existing plants abundantly demonstrated its sterility before the relative recent study of fossil plants placed it upon an altogether new basis.

RELATION OF EMBRYOLOGY AND VERTEBRATE PALEONTOLOGY

By Professor RICHARD SWANN LULL
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THE problem of recapitulation among vertebrates gives by no means as accurate results as among invertebrate forms, for while a single adult shell, if perfectly preserved, will often display the entire life history or ontogeny of the individual, a bone, or even a complete skeleton, is rarely retrospective and if at all only in some minor detail. The vertebratist, therefore, in his study of ontogeny, for comparison with racial history must needs follow either the entire growth of one animal, a thing manifestly impossible when the embryonic stages are considered, or study a long series of individuals in various stages of development, the securing of which in the great majority of cases is largely the result of a number of happy accidents. When one comes to weigh the evidence offered by the actual embryos of fossil vertebrates he will find a very great dearth of material, for fossil embryos—that is, the stages in the life history before birth or hatching—are extremely rare.

Recent embryology, on the other hand, is more productive of results and the earlier stages of certain organs often suggest those of equivalent development in animals of the past. In his interpretation of a given structure, however, one has to bear in mind whether it may not have been modified to suit some modern need in the life history of the individual, and thus no longer give us a true image of bygone structure. These cœnogenetic organs are not historic, but as Wilder says, "have to do with such immediate environmental problems as nutrition or protection." Again, if the organ has approximately the same form

and character in the ancestral type at the same stage of its development, it represents an actual repetition of past history and is therefore palingenetic. Sometimes it is not quite clear, however, under which caption the embryonic structure comes, and its interpretation must be attempted with caution.

Osborn in his lectures to his students speaks of the three-fold evidence for evolution which stands firmly like a tripod, the legs of which are comparative anatomy, embryology and paleontology; and the evidence of each should correspond, provided the interpretation be correct. Of these, however, embryology is manifestly the weakest member, while paleontology is a tower of strength!

The reptiles are so rare as embryos and withal so ancient a group that their ontogeny throws but little light upon paleontology. Among the fossil forms a number of specimens of *Ichthyosaurus* have been found with young contained within the body of the adult. Many of these are in the normal position for fœti-in-utero; others are displaced, with the head directed forward. These latter Branca thinks may be young that have been eaten. There is also, at times, a very great difference in the size of the contained young. Aside from a slight difference in proportions, especially that of head to trunk, and a less degree of hardness of the embryonic bones, as indicated by their being crushed over the parent's ribs, the young teach us nothing as to ancestral structure as they are in every way perfect ichthyosaurs. They do prove, however, when the evidence of viviparity which they offer is taken in connection with the supreme degree of aquatic adaptation indicated, that the ichthyosaurs were high sea-forms, never coming ashore even for egg-laying.

That certain of the dinosaurs were also viviparous may be proved by an embryo contained in the unique specimen of *Compsognathus longipes* from the Jurassic of Bavaria. So far as I am aware this embryo gives no other evidence of ontogenetic value.

The turtles have been made the subject of exhaustive study by Hay and from the embryological point of view by Clark under L. Agassiz. Anatomically they are the most remarkable of reptiles, having undergone during their career an extreme modification in many directions while retaining a number of very primitive characters. The most remarkable feature is the development of the shield or carapace, which contains what are generally considered as the homologues of the ribs of other vertebrates, but, strangely enough, here lying outside of the shoulder girdle, a feature wherein the turtles are utterly unique. The embryology, which is well known, ought to throw some light upon the origin of this important feature. In their earlier stages of development the Chelonia resemble the Lacertilia, the chief pecularity being caused by the development of this carapace which appears in the form

of two longitudinal folds extending above the line of insertion of the fore- and hind-limbs which have already made their appearance. Hence the carapace grows outward and over the limb-girdles which come to lie within the rib-like osseous supports. This ontogeny shows us clearly how the ancestral carapace may have been formed. Paleontology has not as yet confirmed this, but doubtless will do so.

Among birds one of the most interesting features is the occurrence of vestigial tooth papillæ in the jaws of certain embryo parrots and owls —reminiscent of Mesozoic days when birds were toothed in their adult state.

Mammalian evidence is very striking in many details and much of it has recently been summarized by Hubrecht, who makes much of the character of the placentation and derives from it and other features some remarkable conclusions. Hubrecht abandons the idea of the derivation of the mammalia from the reptilian-insectivorean stem, but on the contrary derives them from amphibia-like animals of the Carboniferous. The character of the placentation, moreover, places man, the Anthropomorphæ and the hedgehog among the most archaic of living mammalian types, an idea also borne out by comparative anatomy and one which paleontology may some day confirm.

The most primitive mammals, the Prototheria, are still very suggestive of their old reptilian ancestry in many ways, especially in the method of producing the young inclosed within an eggshell. The position of the Marsupials is surely low in the scale of mammalian life, although they show in many respects remarkable specializations. Wilder compares them with the Prototheria in that they also bring forth their young at a very early state of development, though not protected by an eggshell. The period during which they are permanently attached to the nipples within the pouch is actually post-embryonic and properly larval. Vestiges of placentation have been found in at least one marsupial, a fact which gives color to the belief that in this respect they may be degenerate rather than primitive. Broom has shown that the modern marsupial shoulder girdle passes through a prototherian stage implying a relationship which is strongly supported in other ways.

The fœtal Sirenia and Cetacea, so far as known, show no greater development of hind-limbs than do the post-natal individuals. They do show a marked neck construction and the head bent at right angles with the trunk in a normal quadrupedal posture. The head of the fœtal manatee is very suggestive of the modern ungulate. Ryder has tried to prove the homology of the caudal flukes in the Sirenia and Cetacea with the integument of the hind feet, drawing his evidence largely from comparison with the seals. In the embryo the flukes appear as lateral expansions near the end of the tail, giving it a lance-like form when viewed from above. These flaps by transverse expan-

sion develop into the powerful swimming flukes of the adult. They may be compared with lateral flanges on the tail of the sea otter *Enhydris,* but in the latter the flaps are elongate, while in the Cetacea they are short and situated toward the end of the tail. Nevertheless, the homology of the two types of flange structures appears true, the posterior position and concentration in the whale being a mechanical adaptation which has become accelerated in its appearance so as to be embryonic. The presence of hair on the body of the fœtal whale and of distinct calcareous tooth germs in both upper and lower jaws of the unborn young of whalebone whales are both reminiscent.

The horses, our knowledge of which is so complete owing to the pioneer work of Marsh and later of Osborn, show some interesting points of comparison between fœtus and ancestor. The skulls of prenatal modern horses resemble those of *Mesohippus* or even of *Eohippus* in the proportions of face and cranium, the short-crowned grinding teeth, lesser angle between basi-cranial and basi-facial axes and the fact that the orbit is incompletely ringed with bone. The feet of the unborn foal are also somewhat reminiscent of old-time conditions.

One of the most difficult points to be reconciled in the acceptance of the Cope-Osborn theory of the origin of molar cusps was the apparent non-agreement of cusp ontogeny with the interpreted phylogeny which this theory upheld. The difficulty has been met in two ways: by the supposition that cœnogenesis has entered into the embryogeny, or that the paleontological record as shown by the tritubercul ists is open to a different interpretation. The present great exponent of the idea claims that the matter is still *sub judice* and thus the problem stands.

In conclusion, the paleontological student of the higher vertebrates can hope to find in embryology a host of valuable suggestions, much verification of his work and sundry apparent inconsistencies which must in some way be reconciled. He should ever bear in mind the influence of nature and nurture, the latter often giving rise to perplexing conflicts between the two records. He will on the whole have in embryology a fair mirror of the past wherein, even though the image be somewhat distorted and the more remote reflections dimmed by time, he can view the striking features of the long procession of the ages.

OSERVATIONS ON THE EARTHQUAKE OF MAY 26, 1909

By Professor J. A. UDDEN
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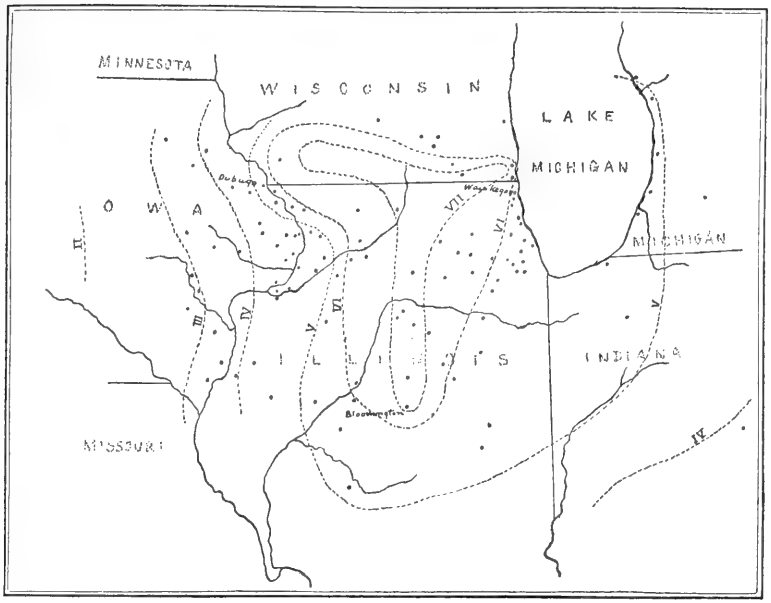
EARTHQUAKES are infrequent in the upper part of the Mississippi Valley, and observations on earthquake phenomena in this part of the world have a peculiar interest, not only on account of the special bearing they may have on seismological questions, but also on account of the light they throw on the psychology of an observant public which is unacquainted with seismic phenomena. The writer wishes to present some observations on the earthquake which occurred in this region on the twenty-sixth of May, 1909. They are based on notices which appeared in the public press, and which were secured from fifty daily and weekly newspapers immediately after the earthquake. The collected reports contained in all some three hundred observations on incidents which occurred during a few moments shortly before nine o'clock in the morning, when the earth waves rapidly traversed the states of Illinois, Iowa, Wisconsin, Michigan, Indiana, Missouri and Minnesota.

The reports collected indicate that the mesoseismal area of this earthquake lay in northern and north central Illinois, and reached slightly beyond the south boundary of Wisconsin. It appears also that there were no less than three epicentral tracts, one near Dubuque in Iowa; one near Waukegan, and another near Bloomington, in Illinois. At all of these places the shock was strong enough to slightly damage a few buildings. From this unusually large triangular mesoseismal area the earthquake waves spread in all directions, sensibly as far north as to Rochester in Minnesota and to Muskegon in Michigan, east as far as to Muncie in Indiana, westward to DesMoines in Iowa, and southward to Hannibal in Missouri, affecting an area of some five hundred thousand square miles.

In the central region, where the earthquakes are most complex, one report states that a distinct raise, or upward motion, was first felt, and that this was followed by a trembling. In other cases, houses and floors are said to have "heaved." In Beloit the houses are said to have been "jostled out of plumb." Violent shaking and rocking is also reported. Farther out from the central area there is a more frequent use by the reporters of such terms as "shaking," "rocking," "swaying" and "jarring," while toward the outer margin of the disturbed area houses are more often said to have been gently rocked and shaken, or to have "trembled" or "quivered," indicating the more gentle and



Isoseismals of the Earthquakes in the Upper Mississippi Valley, May 26, 1910.

more regularly undulating nature of the free and gradually vanishing oscillations of the earth.

The greater number of earthquakes are now known to be due to slipping of enormous blocks of the earth, along fissures or joints of great depths, and thus forming the dislocations known to geologists as faults. In the case of the earthquakes with two maxima of disturbance, the slipping occurs first at one point in such a fissure, and then at another. There can be no doubt that this Illinois earthquake was of the nature of such a compound slip, although the exact position of the fault can not be correctly located from the data at hand. In most descriptions of the shock *no* mention is made as to whether there was one maximum or more. Such particulars were naturally overlooked. The people of the upper Mississippi Valley are not trained in making observations on earthquakes. Nevertheless, nine observers make mention of more than one commotion. One account from each of eight localities states that two distinct shocks were felt. These places are Bushnell, Canton, Champaign, Chicago, Geneva and Sterling in Illinois, and Davenport and Dubuque in Iowa. In the latter place the first disturbance lasted about ten seconds, after which there was a short pause and then again a shock of short duration. But the reports from Chicago, Springfield and Champaign, which places lie on the other side of the mesoseismal area, all agree in stating that the first shock was of brief duration, and that the second lasted several seconds. One observer is reported as having noted three distinct shocks, and this was Professor W. H. Hobbs, at the time on a visit in Madison, Wis. He is

one of America's prominent seismologists, and his testimony may be regarded as specially competent. The three shocks he noted may have been three separate impulses coming from the three epicenters previously mentioned, at Dubuque, Waukegan and Bloomington, started by slippings closely following each other in each of these places.

This inference is in a measure strengthened by some observations made on the duration of the earthquake. There are in all fifty-eight such observations, showing a range of estimates from one second to three minutes. Thirty-eight of these estimates vary from one to eight seconds and average four seconds. In six places the disturbance is reported to have lasted ten seconds; in five places, fifteen seconds, and in one, twenty. An average of these twelve estimates is about thirteen seconds. In two places the shock is reported as lasting a half minute; in three places, one minute; in one, a minute and a half, while in Dixon and Joliet the disturbance continued for three minutes. No great accuracy can be claimed for these estimates, but it will be observed that they fall into three groups, one with an average of four seconds, one with an average of about thirteen seconds and another with an average of about sixty seconds. We may suppose that the shortest average represents places where only one of the three shocks was sensible, while the two larger averages represent places where two or where all three shocks were strong enough to be felt. All places where the disturbance lasted more than a minute are somewhat centrally located, and may hence very well have been exposed to the effects of all the three shocks, each of which increased the total length of the period of the disturbance.

No less than sixty-six observations are reported on the time at which the earthquake was felt. These are of interest chiefly in showing how great is the difference in accuracy of time measurements required for general purposes, and for the purpose of seismic investigations. They also illustrate our general preference for round numbers. The reports range from eight o'clock in the morning to twenty minutes after nine. More than half of them give the numbers thirty, thirty-five, forty and forty-five minutes after eight. Discarding these figures, which are multiples of five, twenty-two observations range from thirty-seven to forty-one minutes after eight. The time recorded by the seismometer in the office of the United States Weather Bureau in Peoria, no doubt more reliable, was thirty-eight minutes after eight. The time marked by another government seismometer in Washington was forty-one and a half minutes after eight. If the velocity of the earthquake wave in traveling from Peoria to Washington, be calculated from these last two figures, we find that it approached three and three tenths miles per minute. For the purpose of determining the velocity of earthquake waves the data furnished by the press reports are of course entirely inadequate.

The location of the epicentral tracts and of the mesoseismal area is,

however, clearly indicated by reports from which the intensity of the motion may be estimated, and from which isoseismal lines may be constructed.

The data contained in the press reports can be readily compared with the Rossi-Forel scale of intensities. The greatest intensity shown is in the falling of chimneys and in the cracking of walls, which barely approximates eight in the scale. It is not practical to separate these localities of greatest intensity from a more extended region where the earthquake had an intensity more nearly comparable with seven in the scale. Within this area furniture was overthrown, plaster fell from ceilings and from walls, and hanging pictures and other suspended ornaments were jerked loose from their fastenings. Outside of this most severely disturbed mesoseismal area there is a belt from ten to a hundred miles wide where the intensity approximates the next lower point in the scale. Here lighting fixtures, chandeliers and bookcases are reported to have swayed, dishes were broken, chairs rocked or were moved or overthrown, houses were rocked, chimneys cracked and clocks were stopped. Beyond this again is a zone where the evidence of the earthquake consisted in the more subdued motions described as shaking of houses and of furniture, rattling of dishes, bottles and tinware and swinging of suspended objects. This zone has a width of from fifty to a hundred and fifty miles and marks the location of the fifth isoseismal. Continuing the diminuendo, the earthquake next announced its rapid passage by the rattle of windows, the jarring and quivering of houses, and by gentle shaking and trembling of furniture. This is the fourth intensity, and characterizes a zone that merges imperceptibly into the next, where few people noticed the disturbance, and where it appeared as a merely perceptible jar, or a slight undulation, most frequently noted only in the upper stories of high buildings. In this gentle form it disappeared to human senses at a distance, in all directions, of some four hundred miles from the central region. How much farther did it speed, unseen, unheard and unfelt? You will remember that it left a record on the seismometer in Washington. This city is nearly four hundred miles beyond the zone where the waves ceased to be perceptible to the unaided human senses. From this record we may infer that in the brief span of two or three minutes the earthquake waves spread over a circular area about sixteen hundred miles in diameter.

A classified review of the little things that happened in the upper Mississippi Valley, when a block of the earth slipped in the northern part of Illinois may perhaps be of interest. The phenomena reported, affected at least five of the human senses, the senses of general well-being, of touch, of equilibrium, of hearing and of sight.

A rheumatic woman in the zone where the disturbance was very feeble "felt the vibrations keenly and told others of the earthquake,

before it was generally known." Another woman, in poor health, ascribed the peculiar feeling that she experienced to an attack of heart disease, and sank frightened in bed. Experiences of this kind have been noted in other earthquakes and appear to be due to a morbidly excitable condition of the ill-defined and unspecialized sense of general well being. Some people perceived the earthquake chiefly through the sense of touch, as when a man, seated in a chair and resting his legs on a railing, "felt his legs shake," or as when a chief of police, also seated, felt that his chair shook. In several other cases the earthquake was likewise merely "felt." No doubt the sense of touch entered as an important element in a far greater number of instances when mention is made that something shook, trembled, quivered or rocked, or when there was a jar or a tremor. The sense of equilibrium or of poise was evidently involved in the case of a man who felt "dizzy," and in the case of people who "wabbled on the streets," in cases where occupants of houses noted a "heaving," "rocking" or a "swaying" motion, and when people "were thrown down," or "nearly tumbled over," or "found difficulty in keeping on their feet."

The reports mention only five instances of sounds accompanying the earthquake. Such sounds are general in the mesoseismal area in all severe earthquakes in all parts of the world, except in Japan, and one noted seismologist believes that their absence in that country is due to a racial inability among the Japanese to hear sounds of very low pitch. The general absence of sounds in the Illinois earthquake is readily accounted for by its comparative weakness. It was faintly audible only in three epicentral tracts. Some parties claim to have heard a distinct rumbling before the shock in Dubuque. In Waukegan one man described the quake as a rush of wind, and said that he had heard it. This swishing noise is one of the many known characteristic forms of earthquake sounds. In Springfield, Ill., a faint rumbling was heard, and a janitor in one of the school buildings in Peoria made a similar observation. One man heard a sound like the "bumping of a locked door." This is another variation of earthquake noises, which, when more powerful, resemble volleys of musketry and artillery, and which, like the other noises, originate under the ground. Many observations involve sounds which are, as it were, proxies of the quake, induced by secondary events, such as the rattling of windows and dishes, the crash of falling brick and the like. The student of earthquakes depends, as we have seen, on such noises for much of his information on the progress of the earth waves in the peripheral region of the disturbed area.

The sense that gives us the most reliable information on earthquakes, as on most other physical phenomena, is the sense of sight. Visible earth waves are, however, rarely seen except in severe disturbances. It is uncertain whether they appeared anywhere in this case.

but there is a suggestion that they were noted in Waukegan, where the sidewalks were seen to "heave." A high bridge near Dubuque, Ia., and some old buildings in Plattsville, in Wisconsin, were seen to "sway." But motions of such structures, as well as motions of smaller objects, indoors and outdoors, are merely the effects of the earth's motion and not a part of the earthquake itself. It is unnecessary to enumerate them here.

Another classification of the earthquake phenomena takes into consideration the different objects giving evidence of the seismic motion and the terms used by the observers in stating how these objects were affected. It presents simultaneously in this case, a study in journalistic diction and in mechanics. Forty reports relate the varied behavior of buildings and houses. These are said to have shaken (17), rocked (7), trembled (4), swayed (3), cracked (3), to have been jarred (2), to have quivered (2) and to have creaked and heaved, respectively in as many cases as indicated by the inserted figures. Observations on dishes, bottles and tinware are next in number. These mostly rattled (15), or were broken (8). Some were dashed to the floor (6), others merely fell (3), some were shaken (3), were moved (2), or they rocked, trembled, wabbled and were disturbed. A crockery store in Dubuque sustained a damage of some eight hundred dollars. The words used in describing the motions of furniture present a turbulence of performances of almost kaleidoscopic variety. Chairs, tables, beds, bookcases, even sedate stoves shook (8), were moved (6), were overturned (3), swayed (2), quivered (2), trembled (2), broke, were upset, tipped over, threatened to tumble over, rattled, rolled back and forth, rocked, heaved and "had the glass shattered." Windows and doors rattled (12), and shook (3), and one door was "sprung so it would not close." Hanging pictures and mirrors engaged in a variety of diversions. Some swung (3), some were shaken from the walls (3) and some were thrown from their fastenings. One mirror "trembled on the wall," and another "fell from the wall." One is said to have "jumped around" and one was "demolished." Light fixtures and lamps swayed (4), heaved, shook, were shaken from their rests, were overturned, fell and broke, or were knocked down, and one gas flame was "shaken out." Chimneys fell (4), toppled over (2), were razed, shaken down and cracked. Water and milk in tumblers and pans were spilled (5) and tippled. At Sabula a wave was thrown up against the bank of the Mississippi River. Bric-a-brac was shaken off, tipped off and thrown down from mantles (6) or simply fell to the floor. Four clocks were stopped. Heavy machinery rattled or "shook in good shape." An elevator swayed and some linotype machines swayed violently. Telephone wires were seen to sway, a telephone receiver was knocked off its hook, and a telephone instrument was "put out of commission." Other public utilities suffered serious damage, several thou-

sand dollars being needed for the repair of disjointed gas pipes in Chicago and its suburbs. Goods were thrown from the shelves in some stores. In the watch works in Elgin some delicate instruments were thrown out of gear, and in a printer's office in Dubuque some type, locked in a form, was pied. A kitten was thrown across a room.

There was one class of accidents, some serious and others comical, which could not have been foreseen as the results of an earthquake. These involve some trigger-like arrangements. Falling stoves and disjointed stove flues caused several fires in Aurora and Chicago. In Waukegan the shock disarranged the bins in a feed store, and some of the grain was let out through a crack between the boards. The leg of a piano was loosened and fell in a school in Oak Park. The whole instrument was in this way upset and tumbled down on the floor, and the accompanying crash and noise naturally frightened the children.

Many reports describe the mental state and the behavior of people on experiencing the unusual sensation of the earthquake. In the epicentral tracts some were terrified, many left, or fled or rushed from their homes, or from buildings where they were working. There were several small panics among laborers and among employees in factories. People were alarmed and excited and ran on the streets. Some schools were dismissed for the day and instruction was interrupted in two university classes. From farther out in the disturbed region some papers state that the people in the upper stories of some high buildings were frightened, and from still further out reports mention that people were surprised or merely that they perceived the physical sensation, evidently unattended by any emotion.

The tendency of the human mind to make inferences and draw conclusions is pointedly illustrated by many of the reports. In cases where the earthquake was not recognized, the disturbance noted was nevertheless invariably ascribed to some cause, more or less remote, but suggested through the bias of previous experience. Many people thought the jar they felt was due to an explosion or a blast in some quarry, and others thought it was due to the moving of some heavy object in the building they occupied. A janitor in a school building thought that a man engaged to repair the flag pole had fallen on the roof. A grocer who had piled up some sacks of flour in the second story, went up to see if these had fallen down. People living near car lines and railroads referred the commotion to passing cars or trains. Residents in the cities were reminded of the passing of heavy vehicles. Two unsophisticated children jumped out of a bed that shook, ran crying to their mother and reported that the bed was falling to pieces. A young lady stenographer in Chicago, more versed in the ways of the world, felt her chair rocking and promptly rebuked a supposed offender at her back with the command: "You stop that."

Projected forward instead of backward, reasoning results in the

vision of things impending. Here also the bias of earlier experience and of training plays an important rôle. Remembering the recent disasters in Europe, Italian laborers in Chicago quit work to fall on their knees and pray. Recalling a prophecy of the coming of the end of the world three days later, some Zionists are reported to have concluded that the earthquake was the beginning of the fulfillment of the prophecy. Some persons who had left their houses, refused for hours to enter them again, fearing a repetition of the earthquake. A prisoner in a jail is said to have speculated on his chances of getting away, in case the walls of the jail would fall, and some people in Chicago feared the coming of a "tidal" wave from Lake Michigan.

It is well known that afferent impulses, especially if they are powerful, have the effect of inhibiting or interfering with central psychic activities. Such inhibition was probably responsible for the forgetfulness of a reporter who sent in his account of the earthquake in a neighboring city to a newspaper in Clinton, but forgot to affix his signature. It explains also the action of a woman in a hospital, who was walking on crutches and who ran out without them, to escape from the building. With the inhibition of man's reason, his instincts take its place, and it would seem that many of our instinctive actions are not much different from those of the brute. They are exemplified in the panics that took place in a few factories and schools. When people rushed from buildings and started to run on the streets, they acted on instinctive impulses. These actions must have been prompted by a nervous mechanism quite like the mechanism that started several runaway horses in places where the earthquake was sufficiently severe to appear alarming. The launching of sensational rumors during a general excitement is traceable to a related instinct, only more refined and exclusively human. The reflex was started on this occasion by a fire in a kitchen in Aurora, and the reaction announced that "Aurora is burning up."

One phenomenon in this connection is almost embarrassing to mention, in view of the present growing sentiment in favor of women's rights and woman suffrage. It appears from the effects of the recent earthquake on the American people, that human reason is more readily inhibited in the gentler sex and in children, than in men. The statement may be worded in another, and perhaps a better way, by saying that human instincts are relatively stronger in woman than in man. This statement will hardly pass as anything new. This distinction is implied in the wording of one report, which states that "men were excited, women and children frightened." It is stated that in Dubuque a panic was narrowly averted in a shop where women worked. In an office building in the same city it happened that the women rushed in a panic to the stairs, and that men met them and quieted them. In a home for young women the jar is said to have "scared the

occupants out." Several panics occurred in schools. One man relates that his wife and sister "rushed to him." Nurses were alarmed in a hospital. Telephone girls left the switch-boards in Chicago, and "were scared" in Clinton. A particular mention is made of a seamstress who was alarmed, and of another woman who sank frightened on a bed. But in no case is a man specially mentioned as having been afraid. In places where men were scared, fright was general, and there was then no cause for such special mention. The evidence of this difference can hardly be charged to an unconscious discrimination by the reporters in favor of the stronger sex. It must be regarded as a noteworthy incident in this earthquake that its intensity was near that limit, which is strong enough to scare women but not men. This limit must approximate seven in the Rossi-Forel scale, and the unsentimental seismologist may hence add another criterion for correctly locating the seventh isoseismal.

One general observation which has a practical bearing should perhaps not be left unmentioned. It is that the earthquake was more strongly felt in the upper stories of high buildings than on the ground floors. In Dubuque "the upper part of the high buildings swayed." A reporter in Burlington says that the shock was "felt most in the upper stories of tall buildings." "The floors shook in the upper stories of large buildings" in Clinton, and in Davenport "the tremors were mostly noted in high office buildings." In Chicago the shock was not felt on the ground floors, but mostly "only in the higher stories." The top floors are especially mentioned as having shaken in some of the university buildings in Evanstown and in a college building at Cedar Rapids. In the architecture produced by the demands of industry and business in this part of the world, the eventuality of a severe earthquake has not entered as an element of consideration. The experience of a half century shows that this neglect is probably justified. Nevertheless, it is appalling to contemplate how different the story of this recent jar would appear if the intensity of the disturbance had been just a little greater than it was. From our past experience we may safely infer that the valley of the upper Mississippi is in a region where earthquakes are not frequent. Are we also justified in believing that when such disturbances do occur, they will not be severe? The violence of the New Madrid earthquakes a hundred years ago makes the answer to this question uncertain. Time alone will tell.

THE METHODS AND USES OF A RESEARCH MUSEUM

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THE average public museum contains natural history specimens of two categories—those which are displayed within glass cases constantly open to the light, so as to be continually in the view of visitors; and of those which are stored away in various appropriate containers, ordinarily protected from the light, and which are not open for the inspection of the general public, though they may be freely handled and examined by the special student in the field to which they pertain. The former category of specimens constitutes what is usually referred to as the museum proper, or exhibition museum; while the latter forms what may be termed the research museum.

The functions of an exhibition museum have been discussed at length, and its claim to recognition as a valuable factor in public education as well as amusement has been too well established to require further proof. It should be remembered, however, that much of the material on display may at the same time be of direct value in research; for it consists in part of such objects as skeletons which are not affected injuriously by light and which may be encased with a view to easy access by the osteologist who wishes to examine them minutely.

It is in the research department of the museum that I believe lies a great value, even though the sight-seeing visitor may know nothing of its existence. The maintenance of a research department on a large scale is certainly justifiable, as I purpose to show, by the importance of the results to be obtained through it from the standpoint of pure science. In an institution, like the Museum of Vertebrate Zoology, which is an integral part of a large university, it may even be warrantable to emphasize the importance of research over exhibition. For the presence of the research museum serves as a stimulus to the university student and as a source of material and information usable in the work of other departments in the university.

In discussing at length the functions of a research museum, in order to have something concrete to use in illustration, I will refer constantly to the institution with which I am connected. Here, although it has been little more than two years since its inauguration, enough of methods and policies have been formulated to furnish data for the basis of this paper.

The functions of our research department, in other words the

energies of our curators and the expenditure of our money allowances, are directed along the following lines:

Our most obvious activity, though not necessarily the most important one, lies in the accumulation of the preservable remains of animals of the vertebrate classes with the exception of those below the Batrachia. I am sure that no one will disagree with me in the claim that the results of our work will be of far greater moment in thus narrowing down the object of our work to a portion of the animal kingdom than if we were to spread it thinly over a greater range of subjects.

The field of our work is the region immediately about us. In other words, it is much less effective to attempt to secure a representation of the animals of the world than to exploit the fauna of a limited area. The Pacific coast is practically inexhaustible, is naturally of easiest access and should be of greatest interest to this institution.

Our collections consist of the skins and skulls of mammals, each individual collected being ordinarily represented by its skin, together, of course, with all dermal structures attached, and the entire skull, cleaned and preserved separately. The entire skeletons of a much smaller proportion of the specimens secured are also preserved; and of the smaller forms the entire animal, a few of each species, is preserved in alcohol for anatomical purposes.

In the class of birds the ordinary study skin is the chief portion preserved. However, the endeavor is made to secure complete skeletons representative of each family at least; and also portions of skeletons of a greater number, consisting of skulls and sterna chiefly. As with the mammals, alcoholic preparations are saved, especially of young birds. The expense and mechanical inconvenience of collecting and storing alcoholics impose a practical limit upon the quantity of material to be cared for in this way.

Reptiles and batrachians are preserved entire as alcoholics. Skeletons should also be prepared and saved, but the difficulty of properly obtaining them has proved so great that as yet we have but few. At any rate, with the entire animal preserved in alcohol it is possible for the special student at any time to take out the skeleton of the reptile or batrachian that it is desired to study.

The museum's policy is, and should be everywhere, liberal as regards the loaning of material to non-resident as well as near-by specialists. Material of any sort is loaned freely to any responsible person any where for the purpose of aiding in his investigations, or as basis of any special study. The value of a museum's hoard of specimens and facts increases in direct ratio to the extent to which they are used. No museum is a success as long as it remains a cold-storage warehouse, closed to ready access by the general student whether he be remotely situated or located within easy reach.

The museum curator only a few years since was satisfied to gather and arrange his research collections with very little reference to their source or to the conditions under which they were obtained. In fact it is surprising to find how little information is on record in regard to collections contained in certain eastern institutions as accessioned previous to about 1885. The modern method, and the one adopted and being carried out more and more in detail by our California museum, is to make the record of each individual acquired, whether it comes in from an outside donor or whether, as is the most usual case, it is secured by the trained museum collector, as complete a history as practicable.

The field collector is supplied with a separate-leaf note-book. He writes his records on the day of observation with carbon ink, on one side of the paper only. The floral surroundings are recorded, especially with respect to their bearing on the animal secured. The behavior of the animal is described and everything else which is thought by the collector to be of use in the study of the species is put on record at the time the observations are made in the field. The camera is as important a part of his outfit as the trap or gun. These field notes and photographs are filed so as to be as readily accessible to the student in the museum as are the specimens themselves.

Furthermore, a rather elaborate system of card cataloguing is maintained in the museum. Three sets of cards, namely, accession, department and reference, which are kept up as a part of the regular work of the curators, enable the enquirer to determine quickly what material is on hand, in what form it is, when and where obtained, and, by following up the cross references to the field note-books, the conditions under which each animal was obtained.

As a matter of routine, each specimen as it is obtained in the field is at once tagged, the label being inscribed in India ink with the exact place of capture, date, collector and field number. The original field number is the same as that under which the animal is at the same time recorded in the field notes. Its original tag is never detached from the specimen, no matter what disposition is made of the latter in arranging the collections in the museum; and so, reversely, the student may quickly trace back again from any particular specimen its history, by referring to the card catalogue and field note-book. In addition to the original collector's number there is added on each label a separate department number by which it is referred to in the museum records and any published articles specifically mentioning it.

It will be observed, then, that our efforts are not merely to accumulate as great a mass of animal remains as possible. On the contrary, we are expending even more time than would be required for the collection of the specimens alone, in rendering what we do obtain as per-

manently valuable as we know how, to the ecologist as well as the systematist. It is quite probable that the facts of distribution, life history, and economic status may finally prove to be of more far-reaching value, than whatever information is obtainable exclusively from the specimens themselves.

At this point I wish to emphasize what I believe will ultimately prove to be the greatest value of our museum. This value will not, however, be realized until the lapse of many years, possibly a century, assuming that our material is safely preserved. And this is that the student of the future will have access to the original record of faunal conditions in California and the west wherever we now work. He will know the proportional constituency of our faunæ by species, the relative numbers of each species and the extent of the ranges of species as they exist to-day.

Perhaps the most impressive fact brought home to the student of geographical distribution, as he carries on his studies, is the profound change that is constantly going on in the faunal make-up of our country. Right now are probably beginning changes to be wrought in the next few years vastly more conspicuous than those that have occurred in ten times that length of time preceding. The effects of deforestation, of tree-planting on the prairies, of the irrigation and cultivation of the deserts, all mean the rapid shifting of faunal boundaries, the extension of ranges of some animals, restriction in the ranges of others, and, with no doubt whatever, the complete extermination of many others, as in a few cases already on record.

If we now had the accurate record of faunal conditions as they were in the Atlantic states a century ago, how much might we not be able to adduce from a study of the changes which have taken place. Now is the opportunity to make such records in our western region. Comparative studies of conditions in the same area at different successive times is bound to bring important generalizations in the field of evolution. It will be seen here how valuable also will prove the collections preserved at corresponding intervals. Changes in conditions will doubtless bring about changes in the habits and physical characters of the animals enduring them.

Another grave danger from the standpoint of the student of natural speciation lies in the introduction of exotic animals. This evil is growing rapidly in the effort to restock regions with more hardy or prolific game animals. If successful from the sportsman's basis, either of two things will happen: the original, native species will become extinct by competitive replacement, or, where the relationships are close, crossing will take place so that the original species will be spoiled through hybridization. There are already instances of both in different sections of the United States. It is highly desirable that a good repre-

sentation of specimens of the pure, native stock be properly preserved in our museums, for future comparison.

I wish here to register an objection to the prevalent idea that experimental methods upon the higher animals under artificially imposed conditions may be expected to lead invariably to the satisfactory solution of evolutionary problems. I have in mind some experiments recently made upon birds. Certain species were kept captive in enclosures in which a relatively high atmospheric humidity was maintained. The experimenter found that within the life of an individual, in fact within a few months, successive molts resulted in the plumages of some of the birds becoming darker. Feathers which were normally marked lightly with black became solid black. The increase of pigment throughout the plumage brought about a conspicuous change in the appearances of the birds, as great a difference as one finds between two near-related species under natural conditions, the one occupying an area of arid climate, the other a region of humidity.

The conclusion from these few experiments, quite generally, but, I feel confident, too hastily, drawn, has been that there may be a "direct influence" of the atmospheric humidity sufficient to bring about the color characters of the different species as we find them under the varying natural conditions; in other words, that it is not a matter of gradual adaptive acquisition subject to inheritance. It is even being maintained widely among biologists that natural selection may have very little to do with the characters of animals as we find them in nature.

I believe that the above experiments, among others carried on in the same way, will, alone, lead to inductions largely inapplicable to animals in the wild. My chief objection is that wild animals brought into confinement at once begin to show irregularities in various structural respects. This is shown sufficiently by studies upon the skeletons of animals dying in zoological parks, a very large proportion of which are abnormally modified in various particulars. This diseased condition undoubtedly begins just as soon as the animal is taken out of its natural surroundings. For the cessation of any one set of muscular activities is bound to bring about immediate changes in quantitative metabolism in the system. Change in food supply directly affects the entire organism, and unusual invasion by parasites ensues with concomitant irregular growths. How then can we expect to get a knowledge of the processes of species formation under natural conditions from the extraordinary physical development or behavior of such animals?

I would urge that it is only through the close and long-continued study of animals in the wild state, that is, under perfectly natural conditions, that we can hope to gather conclusive evidence as to the

causes and methods of evolution. Our research museum has assumed the rôle of recorder of faunal conditions as they are in this age. I reiterate, for emphasis, that I believe its greatest ultimate value will not, therefore, be fully realized until a later period.

But to return to our immediate activities and their justification: The mass of information already at hand brings us face to face with numerous problems of distribution and variation. As our field work is carried on, we learn more and more in detail of the extent of the range of each species of animal, and we are able to recognize more clearly the correlated factors. We are able with more accuracy to define the characters of the local races or subspecies. The study of these "small species" I believe is leading to a better understanding of the relationships of animals and the causes of evolution than if we ignored the slight varieties and contented ourselves with dealing systematically only with the species differentiated so far as to be distinguishable at a glance.

Systematists, either as members of our museum staff or students from elsewhere, who make use of our material, are putting on published record the more important facts of distribution and variation as they come to light. All of this activity leads to the more thorough knowledge of animals necessary for any sort of wider generalization. Our institution is a repository of facts; and no matter what may be said to the contrary by those who undervalue the efforts of the hoarder of facts, it must always be the mass of carefully ascertained facts upon which the valid generalization rests. I have lately learned from no less than three zoologists of prominence that the published scientific paper which does not include some induction or generalization is not worth while. The result, it seems to me, of such a sentiment as this, which is being promulgated among the younger students, is to encourage premature conclusions. The object, in the view of the young research student, becomes the discovery of generalizations, and he is liable to be content with a wholly insufficient basis of facts. We can not expect satisfactory inductions from scanty data any sooner than from inaccurate data. At the same time I do realize that the ultimate value of the facts lies in their service as indicators of general truths. The amassing of detailed facts in any field of science is certainly a commendable pursuit; and if generalizations of wide application are early indicated, so much the better. Our research museum is a repository of facts.

There is a more widely-appreciated function of our institution which is already asserting itself as an important one in the research museum's activities, especially in its connection with a state university: People want to know whether or not a reptile is poisonous; whether or not a bird is beneficial or injurious; whether or not a

"wild animal" is to be feared. People instinctively want to know the names of things. There is the mere curiosity, perfectly laudable, which brings such questions as these to the museum in greater and greater number. It is as a popular source of information that no small part of the curator's time is occupied.

The economic value of birds and mammals to the agricultural interests of the state is one of practical importance. In our field work we obtain a great amount of information applicable along this line; and, further, our staff keeps posted as to the results of the important work carried on by our national government to ascertain the beneficial or injurious effects of wild animals. Either from knowledge acquired directly by ourselves, or from that published elsewhere, we are often able to give the information asked for. The museum is thus constituted a popular bureau of information as regards the higher vertebrate animals of the region with which we are familiar.

The functions of a research museum may be summarized as follows: Collecting and preserving animals of certain groups from a limited region; recording in permanent form all obtainable information in regard to their distribution, variation, economic status and habits; serving as a bureau of popular information as regards the animals of the region worked in; the description and analysis of ecologic and faunal conditions as they are to-day; the publication of the immediately important data obtained, calling attention to whatever generalizations these facts may point towards.

THE EFFECTS OF SMOKING ON COLLEGE STUDENTS

By Dr. GEORGE L. MEYLAN
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THE question of the effects of tobacco upon the smoker has received much attention from moralists, educators, physicians and scientists. The literature on the subject is voluminous. Numerous investigators have experimented upon animals, mainly to determine the effects produced by nicotine. The results of these experiments show that nicotine when injected in animals acts as a strong poison, causing disturbances of the nervous, circulatory and respiratory functions. The problem of determining the effects of smoking upon human beings presents far greater difficulties than the effects of nicotine injections on animals. There is very little agreement in the conclusions reached by the many physiologists and physicians, who have investigated this problem.

Professor Lombard, of the University of Michigan, has shown that in from five to ten minutes after beginning to smoke an ordinary cigar muscular power began to diminish, and in an hour when the cigar was burned, it had fallen to about 25 per cent. of its initial value. The total work of the time of depression compared with a similar normal period was as 24.2 is to 44.8.

According to Dr. Woodhead, of Cambridge University:

> Cigarette smoking in the case of boys, partly paralyzes the nerve cells at the base of the brain and this interferes with the breathing and heart action. The end organs of the motor nerves lose their excitability, next the trunks of the nerves and then the spinal cord. In those accustomed to smoking, it has a soothing effect upon the nervous system, but often acts as a nervous stimulant to mental work, as in reading. In those cases the effect is not due to nicotine itself but to the stimulus of the smoke on the sensory nerves of the mouth, which reflexly stimulate the vaso-motor system and dilate the vessels of the brain. There appears to be less irritation of the brain structure and motor nerves than of the sensory nerves, but the power of fine coordination is decidedly lost.

Dr. Clouston, the eminent English physician, writes on tobacco as follows:

> The use of tobacco has become the rule rather than the exception among the grown men of Europe and America and of some parts of Asia. If its use is restricted to full-grown men, if only good tobacco is used, not of too great strength, and if it is not used to excess, then there are no scientific proofs that it has any injurious effects, if there is no idiosyncrasy against it. Speaking generally, it exercises a soothing influence when the nervous system is in any

way irritable. It tends to calm and continuous thinking, and in many men promotes the digestion of food. To those good results there are, however, exceptions. It sometimes sets up a very strong desire for its excessive use; this often passing into a morbid craving which leads to excess and hurt. Used in such excessive quantity tobacco acts injuriously on the heart, weakens digestion, and causes congestion of the throat as well as hindering mental action. In many people its use tends towards a desire for alcohol as well. I have repeatedly seen persons of a nervous temperament where the two excesses in tobacco and alcohol were linked together. Tobacco, properly used may, in some cases, undoubtedly be made a mental hygienic.

Dr. Pereria says:

I am not acquainted with any well-ascertained ill effects resulting from the habitual practise of smoking.

Dr. Richardson writes of tobacco in the London *Lancet:*

It is innocent as compared with alcohol; it is in no sense worse than tea.

In the Fourth Annual Report of the Henry Phipps Institute, 1908, Dr. Lawrence F. Flick reports that of 443 male patients treated for pulmonary tuberculosis, 72.68 per cent. used tobacco. The result of the treatment was favorable in 38.28 per cent. of the patients who used tobacco, as against 47.42 among non-users. Unfavorable results occurred in 61.7 per cent. of the users of tobacco, and in only 52.62 per cent. of the non-users. Dr. Flick concludes:

Here again, as with alcoholism, we have merely evidence as to the influence of tobacco on the development and mortality of tuberculosis and not upon implantation. . . . The statistics here given, if they have any meaning at all, would seem to indicate that the use of tobacco by males may be one of the explanations why tuberculosis is at present as much more prevalent among males than among females. Tobacco undoubtedly depresses the heart and interferes to some extent with vigorous circulation. It is generally conceded that anything which depresses the circulation interferes with nutrition.

Under the title "The Effects of Nicotine," Dr. Jay W. Seaver published an article in the *Arena,* for February, 1897, in which he gives some statistics of the differences in the physical measurements of smokers and non-smokers among Yale College students. Unfortunately, Dr. Seaver does not give any figures of the actual measurements or the number of cases that he observed. He says:

A tabulation of the records of the students who entered Yale in nine years, when all of the young men were examined and measured, shows that the smokers averaged fifteen months older than the non-smokers, but that their size, except in weight, which was one and four-tenths kilograms more, was inferior in height to the extent of seven millimeters (about ¼ inch), and in lung capacity to the extent of eighty cubic centimeters.

In explanation of the difference in age between the smokers and the non-smokers, Dr. Seaver says:

The difference in age in the two groups points to an age limit to parental restraint, and raises the inquiry as to what might supplement this influence.

In regard to the influence of smoking on the increase of physical measurements of college students, Dr. Seaver says:

The effect of nicotine on the growth is very measurable, and the following figures are presented as a fairly satisfactory demonstration of the extent of the interference with growth that may be expected in boys from sixteen to twenty-five years of age, when they are believed to have reached full maturity. For purposes of comparison the men composing a class in Yale have been divided into three groups. The first is made up of those who do not use tobacco in any form; the second consists of those who have used tobacco regularly for at least a year of the college course; the third group includes the irregular users. A compilation of the anthropometric data on this basis shows that during the period of undergraduate life, which is essentially three and a half years, the first group grows in weight 10.4 per cent. more than the second, and 6.6 per than the second, and 11 per cent. more than the third; in girth of chest the first group grows 26.7 per cent. more than the second, and 22 per cent. more than the third; in capacity of lungs the first group gains 77 per cent. more than the second, and 49.5 per cent. more than the third.

These figures have been widely quoted, and generally considered as affording positive proof that college students who do not use tobacco make far greater progress in physical development than is the case with smokers. Without actual figures of increment in measurements, these percentages signify little or nothing. For instance, the difference of 24 per cent. in stature increment reported might mean that the smokers increased 17 millimeters and the non-smokers 21 millimeters, but no one would attach any significance to a difference of 4 millimeters in stature measurement.

A recent study by E. L. Clarke, published in the *Clark College Record* for July, 1909, shows that 46.3 per cent. of 201 students smoke. The smokers exceed the non-smokers a little in strength and lung-capacity, and 26 per cent. of the smokers won athletic insignia against 16 per cent. of the non-smokers. But in the matter of scholarship, 68.5 per cent. of the non-smokers won honors as against only 18.3 per cent. of the smokers. Mr. Clarke concludes:

1. As a rule the non-smoker is mentally superior to both the occasional and the habitual smoker.

2. As a rule the non-smoker is equal, and probably slightly superior, physically, to all members of the smoking classes except the athletes. It may well be queried as to whether the smoking athlete does not make his gain at too high a mental cost to make it pay. No one would contend for a moment that smoking is the sole cause of these differences. There are numerous other factors that are inseparably linked with it.

The question may be approached from the physiologic, the moral or the economic view-point. In this article, the chief aim will be to determine if smoking exerts any influence upon the physical and mental characteristics of college students; the moral question involved will be considered only incidentally; no attempt will be made to present the economic view-point. The writer, with the cooperation of his assistant, Mr. Hyman Cohen, A.M., made a detailed study of 223 college students from two classes, including all for whom records could be obtained.

PERCENTAGE OF SMOKERS

115 smokers or	52 per cent.
108 non-smokers or	48 per cent.

AGE WHEN SMOKERS ACQUIRED THE HABIT

Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number	1	0	0	2	0	2	0	11	11	18	30	23	16	0	1

AVERAGE MEASUREMENTS OF 145 COLLEGE STUDENTS AT THE BEGINNING OF FRESHMAN YEAR AND END OF SOPHOMORE YEAR

	Age	Weight	Height	Lung Capacity	Total Strength
68 Smokers, 1st.	18.8	59.1	171.8	4.02	582
68 Smokers, 2d.	20.1	62.5	173.0	4.10	685
Difference.	1.5	3.4	1.2	.08	103
77 Non-smokers, 1st.	18.0	59.0	170 4	4.08	570
77 Non-smokers, 2d.	19.6	61.6	172.5	4.28	671
Difference.	1.6	2.6	1.1	.20	101

The smaller number of observations in the physical measurements is due to two causes: first, the physical examinations are optional for students entering with advanced standing in physical education; these students usually take only the first examination; second, a number of students in this group had not yet taken their second physical examination when this study was made. The selection is therefore purely accidental.

It appears from these tables that there is no appreciable difference between the measurements of the smokers and of the non-smokers except in the matter of age. The slight advantage in the average measurements of the smokers at the first examination is undoubtedly due to the fact that they are 8 months older. The slightly larger gain made by the smokers in weight, height, and total strength during the first two years in college is really too small to have any significance.

SCHOLARSHIP RECORDS OF THE 223 STUDENTS

	Average Marks at Entrance	Marks during first 2 years	Failures during first 2 years
223 students	90 per cent.	66 per cent.	7 per cent.
115 smokers	89 per cent.	62 per cent.	10 per cent.
108 non-smokers ...	91 per cent.	69 per cent.	4 per cent.

The differences in scholarship standing between the smokers and non-smokers are distinctly in favor of the non-smokers.

If the only difference between these two groups of students is that the members of one group use tobacco and the members of the other group abstain from it, then it would appear that there is a direct relation between smoking tobacco and scholarship. A further study of these two groups brings out differences between smokers and non-smokers in athletic and social activities.

STUDENTS WHO WON A PLACE ON ONE OR MORE VARSITY ATHLETIC TEAMS

Of 223 students	84 or 37.6 per cent.
Of 115 smokers	47 or 41 per cent.
Of 108 non-smokers	37 or 34 per cent.

This table shows that 41 per cent. of smokers and only 34 per cent. of non-smokers achieved success in varsity athletics.

Of varsity athletes 56 per cent. are smokers as compared with 52 per cent. of all students.

The following table illustrates the same point in another way, giving a percentage of 57.3 for the number of smokers on the various varsity athletic teams during one college year.

PERCENTAGE OF SMOKERS ON VARSITY ATHLETIC TEAMS DURING THE SEASON OF 1908–09

	No. of Men	No. of Smokers	Per Cent.
Baseball	13	11	84
Soccer	11	7	63
Swimming	14	11	74
Crew	12	4	33
Hockey	7	4	57
Lacrosse	12	6	50
Basketball	6	1	17
Wrestling	7	4	57
Gymnastic	11	5	45
Fencing	3	2	67
Total	96	55	Average, 57.3

Participation in the social activities of college life is best measured by membership in college fraternities. The following table shows the relation between smoking and membership in fraternities:

STUDENTS WHO BELONG TO COLLEGE FRATERNITIES

Of 223 students	66 or 29.4 per cent.
Of 115 smokers	49 or 42.6 per cent.
Of 108 non-smokers	17 or 15.7 per cent.

This table shows a very close relation between smoking and membership in college fraternities.

SCHOLARSHIP OF STUDENTS WHO BELONG TO COLLEGE FRATERNITIES

	Average Marks at Entrance	Average Marks during first 2 years	Average failures during first 2 years
223 students	90.0	66.0	7.0
66 fraternity members	85.4	59.1	12.8
49 fraternity members smokers	84.0	56.6	14.4
17 fraternity members non-smokers	89.4	66.5	8.1

In order to show more clearly the facts brought out in the previous tables, the following comparisons are made:

Of 223 students ..... 115 or 52.0 per cent. are smokers
Of 96 athletes ..... 55 or 57.3 per cent. are smokers
Of 66 fraternity men ..... 49 or 74.2 per cent. are smokers

There are more smokers among athletes and a great many more among fraternity men than among all students.

Of 223 students .....84 or 37.6 per cent. made varsity teams
Of 115 smokers ..... 47 or 41.0 per cent. made varsity teams
Of 66 fraternity men ..... 41 or 62.1 per cent. made varsity teams

There are more athletes among smokers and a great many more among fraternity men than among all students.

	Average Marks at Entrance	Average Marks in first 2 years	Average failures in first 2 years
223 students	90 per cent.	66 per cent.	7 per cent.
115 smokers	89 per cent.	62 per cent.	10 per cent.
84 athletes	90 per cent.	63.2 per cent.	8.4 per cent.
66 fraternity men	85.4 per cent.	59.1 per cent.	12.8 per cent.

Smokers, athletes and fraternity men have lower scholarship records than other students.

There is some definite relation existing between smoking, participation in athletics, membership in college fraternities and low scholarship. These relations indicate that the factor of smoking can not be isolated from other related factors which may account for differences in age and scholarship. It is very clear, however, that students who use tobacco invariably rank lower in scholarship than students who do not smoke.

Those who are conversant with present conditions in American colleges, recognize two distinct types of students. President Butler, in his annual report for 1908–09, devotes several pages to a discussion of this subject; among other things he says:

Not so many years ago there were few boys who went to college without a serious, definite purpose more or less scholarly in character. They were looking forward to the ministry, to teaching or to the practise of law or medicine. Not many of them had in mind a career as merchant, financier or corporation official. With the lapse of time and the increasing wealth of this country, this condition has been very much changed. It is now fashionable to go to college, at least to some colleges, and the attractions of college life and companionship are powerful motives in leading young men to strive to surmount the barrier of college admission. This new type of college student, whether he knows it or not, goes to college primarily for a social, not for an intellectual, purpose. His wish is to share in the attractive associations of an American college; he desires to participate in athletic sports; he hopes in after life to mingle freely and on terms of equality with college-bred men. It is a good thing that boys of this type should go to college, provided that the college will recognize their existence as a type and will deal with them accordingly. To try to turn such men into scholars is a hopeless task. They are not fitted for high scholarship and they do not desire it.

The type of student referred to by Dr. Butler is a good fellow, he dresses well, has a generous allowance, belongs to a fraternity and tries to "make" some varsity team; he elects courses partly because they are easy and partly because the instructor is popular; he spends much time in social intercourse and athletics, and gets few high marks, mainly because he does not try to get them. This is the student who smokes, because he has the time, the money and the opportunities to indulge in the practise.

The non-smoker usually belongs to another type of student. He is the scholar who is ambitious for rank. Many students of this type earn part or all of their expenses by tutoring and other remunerative work; many of them hold free scholarships and must maintain high rank in their studies to retain them. Students of this type have little time for athletic training or social life of fraternities, and therefore few opportunities and incentives for indulging in the practise of smoking.

There are three points of interest brought out by this study:

1. College students who acquired the smoking habit before entering college are about eight months older at entrance than the non-smokers. Three factors are probably responsible for this difference in age: (*a*) all scientists who have studied the physiological effects of tobacco upon man and animals are agreed that it has a depressing influence upon the heart and circulation, also, that anything which interferes with the vigor of the circulation has a retarding effect upon growth. It is therefore possible that smoking may retard both physical and mental development; (*b*) the age seventeen is the time when most boys begin to smoke, if for any reason a boy is older than the average when he enters college, there is more than an even chance that he will have acquired the smoking habit in the secondary school, and (*c*) the type of student described above who is primarily interested in social life and athletics, is found in secondary schools as well as in college; three out of four of such students smoke, and they are usually graded low in their studies, these facts would account for a higher average age among entering freshmen who are smokers.

2. The physical measurements of freshman smokers are slightly above those of the non-smokers, and the smokers gain more than the non-smokers during the first two years in college, except in lung capacity. These figures are susceptible of misinterpretation unless three important facts are taken into consideration. (1) The smokers are 8 months older than the non-smokers; their measurements should be slightly larger on that account. (2) It was shown that smokers belong to a class of students having larger means and therefore a more favorable physical environment—better nutrition, etc.—than the non-smokers; their measurements should be larger on that account. (3) It was shown that smokers participate in athletic exercises more than the non-smok-

ers; their measurements should be larger on that account. That the smokers are not appreciably heavier, taller and stronger than the non-smokers may be due to the depressing influence of nicotine on the circulation and the consequent interference with normal growth.

3. The scholarship standing of smokers is distinctly lower than that of non-smokers. The intimate connection existing between the smoking habit and participation in the social and athletic activities of college life makes it impossible to determine how much, if any direct influence the smoking habit exerts upon scholarship, but the results of this study and the similar results obtained at Clark College indicate very clearly that the smoking habit is closely associated with idleness and lack of ambition for scholarly achievement.

Conclusions.—The writer has no desire to defend the use of tobacco. The motive in making this study was to ascertain the facts concerning the effects of tobacco upon college men. The teaching of hygiene is making rapid progress; quantities of new books are being published in which the large volume of new scientific facts on nutrition, muscular exercise, and the effects of alcohol take the place of the dogmatic statements and easy moral of the old books; a similar change is desired in the treatment of the problem of the effects of tobacco.

A study of the literature on the effects of smoking, years of medical examinations of boys and men, experience in teaching hygiene and the results of this study have led the writer to the following conclusions:

1. All scientists are agreed that the use of tobacco by adolescents is injurious; parents, teachers and physicians should strive earnestly to warn youths against its use.

2. There is no scientific evidence that the moderate use of tobacco by healthy mature men produces any beneficial or injurious physical effects that can be measured.

3. There is an abundance of evidence that tobacco produces injurious effects on (*a*) certain individuals suffering from various nervous affections; (*b*) persons with an idiosyncrasy against tobacco; (*c*) all persons who use it excessively.

4. It has been shown conclusively in this study and also by Mr. Clarke that the use of tobacco by college students is closely associated with idleness, lack of ambition, lack of application, and low scholarship.

THE DANGER OF UNSKILL

By WALTER G. BEACH

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TWO human streams pour ceaselessly into the sea of American industry. One of these brings to us the immigrant, the man of foreign stock, alien in blood and customs, and more and more from the backward and "beaten" peoples of eastern Europe. The sources of the other stream are in our own life, and upon it are borne America's own children who, in the passing of years, are to face the duties of manhood and womanhood. These two streams fill the vast national reservoir of labor upon which depends in large measure the future of American industry and American moral welfare. This is the first fact to which attention is directed.

The second fact is the changing character of industry, aside from its human element. We are in the midst of the great mechanical revolution whose beginning in America goes back to the early years of the nineteenth century, but which since the civil war has been uprooting the old order, supplanting its simpler methods with marvelous rapidity and tremendous power.

The human consequence of this revolution is the driving out of the man by the machine, on the one hand, and the increasing specialization of labor on the other. And the labor supplanted by the machine, if it is to fit into the resulting more specialized employments, must have skill. Primitive man was unspecialized and his skill was of the slightest, his knowledge being insignificant. The man of to-day finds that sheer muscle is at a discount, and his weaker but better trained fellow passes him in the race. It is not meant that there is not a great demand for unskilled labor, but the unskilled laborer works under a constantly growing handicap.

In our earlier national history, it was possible for us to rely for prosperity upon the resources of nature. Force of body and character sufficient to brave the hardships of a raw and untrained world, and to pluck from nature the bounties which she furnished in abundance, was the quality most essential. Each man or family was a unit in production; cooperation or combination on any extended scale involving training, was not found or needed. Individualism and the overthrow of nature, and her exploitation, were the important features of our national life which assured success; and it was just these qualities of endurance, courage, force, assertiveness, aided by sheer muscle, which the selective

process of our early immigration brought to us. Only men and women of such qualities could and would face the long and dreary sea voyage and brave the peril of the unknown new world. Only the man of hope, of ambition, poor in the wealth of the world, but rich in determination, force and foresight, was suited for such migration. So too, it often was the leader of the advance movement of civilization in Europe who, because of political oppression, led a vanguard of the best blood of his country to share the bounties of nature in America.

But the day in which we can rely for prosperity upon nature's bounty is past. Her resources have been explored and divided up. And while new resources continue to be brought to light, they are the possession of the few, and offer little of hope to the hungry immigrant from the old world.

We can not, therefore, depend exclusively upon nature and the raw force and determination of our people to maintain or continue the old-time progress and high position of America. More and more our dependence must be placed upon ourselves rather than upon nature alone, and in particular upon a character acquired through training. The new industrial life, it has been said, demands skill. If America is to advance in industry, she must face this demand; her people must be trained and trained industrially.

If such is a true statement of the general character of the productive process of to-day, it is pertinent to inquire if the two streams of humanity, which furnish the labor necessary to production, are fitted to the more specialized demands of this process. Is our labor skilled? And what are its means of attaining skill?

Let us consider first the stream of immigration. The report of the commissioner general of immigration for 1907 shows that out of the total number of 1,285,000 coming to this country from other parts of the world in the year 1906, about eighty-three per cent. were without skill requisite to enter a skilled industry. If we eliminate from this number the women, children, aged and such other persons as are described as having no occupation at all, there remains fifty-nine per cent. of the total who are of industrial age and sex and yet are distinctly unskilled laborers. A large number, too, of those excluded are women who will enter unskilled trades, and many are children who will begin to earn at the earliest possible time in unskilled employments.

The fact that such a large proportion of the immigrant population is unskilled is inevitable. It is necessary only to recall that the great influx of the present and recent past is from central and southern Europe, from regions in which the opportunity to acquire skill is comparatively slight, and where the call for skill is not yet dominant.

If it be agreed, then, that the stream of immigration is pouring a mass of unskilled labor into our country, consider what is the case in

regard to the second source of our industrial life. What is the tendency to skill and the opportunity to acquire it among our own children who must soon enter industry? It is impossible to state this problem in a statistical fashion; but a fair idea may be obtained from a study of the industrial situation. Skill may be gained through two, and only two, methods. It must come either in connection with industry itself or in some way of preparation outside it; either through a system of apprenticeship or by way of vocational schools or school studies. In the older state of industry, the apprentice system of the guilds constituted a logical and efficient method of training. Boys became skilled workers under direction of a master and in the actual work of production. The apprentice system was the great industrial school of the past, and not only because it led to industrial skill, but also because it gave at least something of that mental discipline and power which we associate with the idea of a school.

This system, as is well known, is largely a thing of the past. It is true that apprentices are now received in some industrial plants, but the number so received is entirely inadequate to furnish a supply of skilled labor for the many lines of trade and industry. It is enough to say that the modern factory with its great specialization, is not as a rule, willing to train its skilled workers. It wishes its workers to come to it already skilled.

If training can not be gained as a part of the actual productive process, may it be acquired outside that process? Or, to state it differently, does our school system give the members of the growing generation a training which fits them to enter the industrial life as skilled workers?

We have in this country a considerable and growing number of trade schools and technical schools. We also find evening schools where vocational training may be obtained; and there are other opportunities of a similar sort. But it is not necessary to prove that there is but a scant beginning in this direction, as this is admitted by all students of the subject. It is clear that our present means of training for trade and industry through special schools is entirely inadequate, and it is equally well admitted that our common school system does not meet the need in this direction. Its curriculum has been determined by other interests than the economic needs of a constantly increasing industrial population.

In the excellent study by Professor Thorndike,[1] based upon returns from schools of twenty-three cities having a population of 25,000 or more, it is demonstrated beyond a doubt that the lack of opportunity for vocational training is a great cause of that heavy dropping out of school in early grades which thereby closes school education to a large

[1] "The Elimination of Pupils from School," p. 118 ff.

proportion of our children. Dr. Thorndike finds that only twenty-seven per cent. of those entering the first grade of the common school continue into the first year of the high school; and of these, thirty-seven per cent. drop out by the end of the first high-school year. The main cause of this enormous elimination from the high school has to do with the nature of the high-school course of study. Evidently a considerable number begin the high school at the age of fourteen or fifteen, an age at which little skill has been gained, yet which is favorable to its acquisition, but are discouraged by the lack of opportunity in this direction and so leave school altogether.

As is well known, it was found by the Massachusetts Commission on Industrial and Technical Education that "25,000 children between fourteen and sixteen years of age are at work or idle," that is, not in school; and the result of this careful investigation was to make entirely certain that these children had dropped out of school because they did not find there any possibility for training along lines which would prepare for the making of a livelihood.

We must conclude, therefore, that neither within the organization of industry itself, nor outside of it, in schools of any type, is there opportunity for the stream of growing boys and girls to gain in an economic manner that degree of vocational training which the conditions of modern industry demand.

What then is the situation which we face? First, the demand of our specialized commercial and industrial life for a larger and larger percentage of skilled workers. Secondly, a stream of foreign immigration pouring upon our shores an unskilled population much of which could not acquire skill readily, even if opportunity were presented, and which must inevitably supply largely the demand for unskilled labor. Third, a stream of growing boys and girls who must earn their living through our present complex and specialized forms of industry. Fourth, a comparatively slight chance of their gaining skill after they enter the industrial life, and no adequate opportunity to gain skill through the school before entering upon this work. What is the result? A demand for trained men and women, on the one hand, and on the other a vain beating against the bars which defend the skilled positions, by a mass of desponding, dissatisfied unskilled workers, with only the most venturesome and aggressive pushing through into skilled positions in a manner harmful and exhausting to themselves and weakening to the nation.

It is at this point that the real menace of unskill becomes clear. Much has been written and spoken about the retarding effect of unskill upon our national production, and this is indeed serious. But the real danger is more fundamental. Of greater importance than the product of labor is the worker himself. The effect upon our people of such a

situation as has been described, is the real danger. The problem is not primarily industrial but social. Unskill in the face of a demand for skill leads to degeneracy. In this fact lies its greatest menace. In his admirable study of "Misery and its Causes," Dr. Devine wisely suggests that the great cause of misery is maladjustment, and there is strong reason to think that his conclusion is correct. But just in so far as it is true that economic facts lie back of and condition the progress of civilization, to that extent failure to meet the fundamental economic facts involved in advancing stages of industry must constitute or lead to the greatest social maladjustment and consequent degradation and misery. It is maladjustment in respect to the most vital phase of life.

A great proportion of the young people of our country must enter an industrial calling. In what way does this unfitness for it affect their lives? The result is best shown by the often-quoted finding of the Massachusetts Commission on Industrial and Technical Education, for 1906. Out of 25,000 young people of from fourteen to sixteen years of age in that state not in school, it is reported that thirty-three per cent. were in absolutely unskilled trades and sixty-four per cent. in what are called low-grade industries, where the skill of the workers is very slight. Only less than two per cent. had found their way into really skilled industries. What does it mean, humanly speaking, to have a child employed in an unskilled industry? Simply that the child usually has come to the end of its development. On the side of industry it means a permanently small production and low earning power; on the side of the individual life, it means a stagnant mind and the consequences which flow from it. For it is not true that children remain in these low-grade occupations for a brief time, and from them pass to higher and more skilled employment. The nature of industrial and commercial technic is such that there is a chasm between unskilled and skilled employments. There is no passage from one to the other. The elevator boy or messenger boy is not being trained to be a mechanic or a telegrapher or any other more or less skilled worker. These and other low-paid juvenile employments represent a class of work of a special sort from which there is no exit and which rather unfit than fit one for better work. In the street trades, in candy-making, in cotton, woolen, knitting and other mill work, and in many other places such work is found. To a considerable extent it is work which should be done by machines and not by growing boys and girls. The child who leaves school to enter one of these positions, condemns himself in the majority of cases to an unskilled life. He passes from one unskilled position to another, becoming more and more discontented as he finds it impossible to advance in wages and responsibility. Discontent, hopelessness, shiftlessness, take the place of ambition and progressive force. The

unskilled employment is not disciplinary and it does not lead to a skilled employment which is disciplinary. In the organization of industry, the avoidance of waste is a great aim; yet the lessening of the greatest of all wastes—the waste of life—receives scanty attention.

The writer of "The Long Day,"[2] in drawing upon her own experience as an unskilled girl, looking for employment in a great city, summarizes the situation in these works:

> For sad and terrible though it be, the truth is that the majority of "unfortunates," whether of the specifically criminal or of the prostitute class, are what they are, not because they are inherently vicious, but because they were failures as workers and wage earners. They were failures as such, primarily, for no other reason than that they did not like to work. And they did not like to work, not because they are lazy—they are anything but lazy—but because they did not know how to work.

And again the same writer records her conclusions in regard to the educational need of girls in view of the modern demand for skill:

> And there are other things more important than the "three R's" which she should be taught. She should be taught how to work—how to work intelligently. She should be trained young in the fundamental race activities, in the natural human instincts for making something with the hands or of doing something with the hands, and of taking infinite pleasure in making it perfect, in doing it well.[3]

And it may be added that what is true of girls is equally true of boys. The great cause of failure and resulting degeneracy is lack of training.

It must be recognized that the vocational impulse is deep-seated, and as the child advances into youth he begins to look to the doing of his life's work. He is restless with simply academic subjects, however valuable. He is concrete in his demands. He wishes to do and earn. But it is an interest in the deep human instincts and forces which must be laid hold of, if we are to develop a healthy, hopeful life; and among these we must recognize the economic instinct leading to the desire to earn and to make a place in the world of production. How much of progress flowed from the development resulting from the vocational education of the apprentice of the guild organization, it is not possible to say; but it certainly was a factor of no small import. And the close association of the wonderful expression of artistic genius in Italy with the development of the skilled artisan and craftsman, is a feature of social history which should lead to serious reflection.

But, further, lack of skill means insecurity of employment for adult workers; and no greater danger threatens labor than this. Every slackening of trade, every depression of business, every interference with industrial progress, every mistake of judgment of the organizers of industry, falls with heaviest force upon the unskilled. Their value in

[2] Page 277.
[3] Page 294.

industry is least, their tenure of employment is most easily imperilled. The past two winters with armies of unemployed in every large city, recruited largely, we are told by competent observers, from the unskilled, bear witness to this fact.

A consequence of economic insecurity is a weakening of moral tone and grip; this is the greatest of all dangers to society. "Every great industrial crisis leaves behind it," says Dr. Warner, "a legacy of individual degeneracy and personal unthrift."[4] "Involuntary idleness intensifies and perpetuates incapacity." Nothing so begets failure as the consciousness of failure. The discipline of regular and continuous occupation is a support which few can do without. At the recent meeting of the British Association for the Advancement of Science, a member of the Royal Commission on the Poor Laws held that pauperism arises mainly from the casual worker class, that is, in the main, the unskilled class whose security of employment is slightest and whose mental attitude is therefore least hopeful and healthy. To live on the edge of social existence blinds the eyes to the social order which is not near the edge. Hopefulness of mind is a social force impossible to measure. It is hope which marks the difference between slavery and freedom, between stagnation and progress. But insecurity weakens and destroys hope, and if employment continues to be insecure, the result must be an increasing body of hopeless men and women, feeding, inevitably, the ranks of criminal and pauper degeneracy.

Viewed from this point, the significance of unskill becomes tremendous. Lack of skill stands as the bar to mental progress even in an unskilled age; but in an age demanding skill, the lack of it is itself a condition leading to degeneration. Through unskill, labor is condemned to low wages, a narrow outlook, an inability to meet the modern demands of industry; by remaining economically unfit, men become socially unfit and are forced for themselves and their children into the ceaseless round of struggle for bare subsistence, with consequent hopelessness, bodily decay and resultant misery. It should be clear that in refusing to meet the industrial needs of our age for skilled workers the nation is condemning a considerable part of its population to an inevitable economic unfitness and resultant mental sterility, since economic well-being is essential to mental stability and progress. Degeneracy, thus, is born of the unskilled hand and the untrained mind.

There is one further position which needs to be considered. It is becoming clear, as investigation into social life proceeds, that human progress depends largely upon society's creative minds, its "inventors," its originators, whose fertile ideas are passed on to the mind of the mass of mankind. It is these suggestive and fruitful ideas which mark the stages of advancement and which constitute the essence of civilization.

[4] A. G. Warner, "American Charities," pp. 103 and 97.

And it may be said, further, to be a matter of at least large probability that these creative minds may be brought forth in any stratum of society. Whether they shall develop and give to civilization the benefit of their talent, depends upon the conditions surrounding them. They may grow and become mentally fruitful, or be repressed and become sterile, according as social environment is favorable or the contrary. It would seem that society should make every effort, in its own interest, to encourage their nurture and preservation. But, as Dr. Ward has so well shown,[5] education is the greatest social agency for providing that the mind, strong by nature, shall develop and give its ideas to the world. How great therefore is the urgency that society should afford educational opportunity to all classes of its people. How great a part of the possible progress of the race or nation is hindered by the social waste of its creative ability which never arrives at its period of fertile productiveness for lack of suitable social opportunity.

It should, however, be clear from what has already been said that the only education which can reach the masses of a nation and hold them long enough to be of educational service to them, is that which looks toward vocation. And it therefore follows that only by making our school system, to some degree, industrial and vocational, and thereby holding our children under educational influences for a longer period, can the great number of productive minds, born in poverty or other unfavorable conditions, be preserved and brought to that stage of development in which they may advance the nation.

Here, then, is the real danger of unskill. Modern industry calls for skill. In the face of this demand, lack of skill leads to unemployment and so to social weakness. Lack of skill leads, also, to poor employment; and so, likewise, carries men into shiftlessness, discontent and degeneration. On the other hand, skill breeds hope and hence mental development. It opens new avenues of activity and draws out otherwise buried talent, and thus preserves the originators to the race. But our two streams of labor are inadequately trained for the economic demand. What we should do in regard to the stream of immigrants is a problem by itself. But as for our own children, the demand for opportunity to gain that skill, which will enable them to fit the economic life of to-day, is a very urgent and vital one.

[5] "Applied Sociology," chapter X.

BACTERIOLOGY AND PARASITOLOGY IN RELATION TO AVIAN DISEASES

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DURING the last ten years the sciences of bacteriology and parasitology have been established beyond previous expectation. To-day these sciences are so far-reaching that they not only have to do with medicine but extend into the realm of hygiene, agricultural sciences and the industrial arts. The advances made in connection with the life histories of the various microscopic animal parasites and the studies which have led to a general understanding of the relation between parasite and host have done much toward unearthing mysteries of diseases which attack domestic fowls and menace the poultry industry. Bacteriologists have enabled the avian pathologist to study and control these fatal diseases.

Practical applications of bacteriology to the arts and industries are only instances of the ramification of this science. In agriculture and closely allied science, bacteriology and also parasitology have been immediately and intelligently employed to set forth new facts and expose new problems. During the last few years bacteriology has held close relations with medical science. By the application and extension into the field of protozoon pathology one of the latest and most helpful developments in the study of infectious diseases has evolved. This is not alone true of human pathology, but must include avian, insect (such as bee and silkworm), sheep, swine and cattle diseases and possibly the diseases of plants.

In the poultry yards epidemics of the so-called "white diarrhœa," "black-head" of turkeys, and tape-worms, have demanded scientific study for remedial help. The loss to the poultryman is at present almost incalculable. The etiology of many diseases is understood only by the discovery of some bacteria or parasite. The mode of entrance of the invading microorganisms to the avian body, the study of the original source of the infectious material and the possibilities of transmission and infection can be apprehended only through prosecution of detailed bacteriological and parasitological studies. Individual birds may suffer from malnutrition and be afflicted with ailments which may be the result of inability to utilize food properly, but when a whole flock becomes droopy. listless and unable to maintain normal life, we must resort to the field of parasitology or bacteriology for the cause.

In the warfare against the ravages of disease a most rational hygiene of the poultry yards must be observed, and in order to understand thoroughly those factors which have to do primarily with eliminating the trouble, it is to the use of disinfectants and antiseptics that we must resort. Here again the science of bacteriology lends a helping hand, for data concerning the efficiency of disinfectants can be ascertained only by bacteriological technique. It then becomes the duty of the scientist to direct his entire attention to those factors which in themselves are sufficient to allow a foothold for many an infectious disease. It is no less a fact among domestic birds than with human beings, that infection may take place by contaminated food, the particular parasite or organism being transmitted in such manner. All the modes of spread are recognized, and just as the spread of human diseases are held to be matters of public concern and preventive measures are instituted by expert bacteriologists, so also should the spread of diseases among domestic fowls be of the same great concern to the poultryman if he is desirous of maintaining his birds in a healthy condition.

Probably one of the most difficult problems in relation to avian diseases lies in the prompt recognition of the cause, so that measures may be employed immediately to allay the trouble. With the large poultry farms it may appear that careful observation of hygienic measures involve too much time, but under many circumstances and especially at this infant stage in our knowledge concerning avian diseases the application of searching and delicate parasitological and bacteriological tests are often necessary to determine the proper method of procedure.

The great losses to poultrymen from the disease known as "black head" or "coccidiosis of turkeys" has called scientific men to make thorough investigation and a specific parasite known as a coccidium has been claimed to be the cause. Dr. Geo. B. Morse, of the Bureau of Animal Industry, United States Department of Agriculture,[1] states that this coccidium may infect turkeys, ducks and pigeons. It has a definite life cycle. He describes it as a certain circular, sometimes slightly oval, cyst, 12 to 25 microns in diameter, containing granular matter which may fill the cyst or occupy only a portion of it. These are permanent cysts and may be voided in the feces of the bird. These only require warmth and moisture for their development into sporozoites by which the disease is transmitted to other birds. By the destruction of the malarial parasite within the body of man, we may break the life cycle and thus interrupt the continuity of the transfer between man and mosquito in the transmission of this disease. In like manner, the scientist can plan to break the cycle of these avian parasites within the

[1] Circular 128 (1908), Bureau of Animal Industry, Dept. of Agriculture.

body of the bird and consequently eliminate infection. Contributions from the Division of Biology of the Rhode Island Experiment Station have furnished us interesting facts concerning parasitism of *Cytodites nudus,* a mite and *Hæmaphysalis chordeilis,* a tick and these are but a beginning to the study of such parasites affecting birds. It demonstrates the field for research in parasitology and what contributions from this realm of science would mean in determining the cause of so many diseases, the etiology of which at the present time is unknown.

Fowl typhoid, cholera, tuberculosis and hosts of other afflictions were discovered through the aid of scientific bacteriologists. In a very recent publication[2] Professor Rettger, of Yale University, has demonstrated the value of bacteriology, by his valuable contribution to the study of white diarrhœa. He has been able to demonstrate the rôle of bacteria in the etiology of this disease. We need no better example of the usefulness of such a science in planning investigations of this nature. By thorough bacteriological methods he has been able to give us the results of his work and has shown how infection may occur, what it means to the poultry industry, and methods of prevention. This also demonstrates how bacteriological methods have been used to study epidemiology. It has given a procedure based on bacteriological facts and with such methods at hand we are supplied with the means of suggesting treatments which undoubtedly will do much toward solving the problems which have heretofore been unsolved. These studies have shown that the function of pure water and food and sanitary conditions are essential to the daily life of domestic birds. If diseases of the poultry yards are to be suppressed, hygienic measures must be observed here as with human beings. It was not until after the introduction of hygienic measures such as a proper sewage disposal, and water filtration that the death rate of typhoid fever was perceptibly diminished in this country and Europe.

Conspicuous as the achievements have been in bacteriology, it can not be said that the field is exhausted. There is hardly an infectious disease of the poultry yards which does not have to do with some bacterium or parasite, and the variations and adaptations of these pathogenic forms is to-day one of the difficult problems with which the avian pathologist has to deal. It is for the scientist to determine whether certain bacteria and parasites owe their pathogenic action to the organisms themselves or to their toxic or poisonous by-products. The field of immunity as related to avian pathology is unexplored. This would be among the most complicated that the scientist could undertake, yet the fields of bacteriology and parasitology with its many perfected methods of attack would indicate that it is not impossible. Not only human medicine, but also veterinary science owe much of their ad-

[2] Bulletin 60, Conn. Agr. Exp. Station.

vancement to these two fields of knowledge. The scientific contributions of Neuman on parasites show that such organisms are the cause of many a dreadful disease, not only with man and animal, but with all avian life. The careful study of their life histories should appeal to our protozoologists and inspire them to contribute to our knowledge of those parasites which are causing an enormous mortality of our most valuable birds.

After the removal of a sick fowl from the flock a diagnosis is usually made. Very often the specific organism causing the infection is readily discovered, while, on the other hand, the most diligent scientific efforts may fail to reveal the character of the disease. Many failures are accountable because there is a lack of sufficient knowledge or a lack of thoroughness in making the investigation.

The fundamental difficulty in ascertaining more definite knowledge about our poultry diseases is the lack of enough scientific men to take hold of the situation. To-day we have no rational system of medical treatment for birds, nor can one be looked for until scientists, who are busy on anatomy and physiology of avian life, offer to the layman a definite plan of procedure, when these parasites and bacteria have made their way into the body and brought about pathological lesions.

The relation of bacteriology and parasitology to the infectious avian diseases as mentioned before, is fundamental. If bacteriologists and protozoologists will enter upon this field of avian diseases as a basis for their research in their respective fields, the results of their investigations will lead to an improvement in the conditions of our poultry yards, and give facts which are necessary before any treatment can be found. With men of this character at work upon avian pathology, success is inevitable.

THE RÔLE OF SELECTION IN PLANT BREEDING[1]

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WHEN one attempts to give some idea of the principles and of the methods and scope of plant breeding, the matter falls naturally into two parts, the rôle of selection and the rôle of hybridization. This is not because the subject is really thus separable, but because the methods in use fall into these categories. One must, of course, use selection after hybridization, but there are a number of plants of great agricultural value, in which either the flowers are too small for artificial crossing or in which other reasons make it desirable to use simply selection in their improvement. It is of these that this paper will treat.

The particular work discussed has been selected because it will illustrate certain principles, not because it is regarded as more important than other work of like nature. The work of many quiet men who are striving for the good of mankind by their efforts toward the improvement of plants deserves to be mentioned, but unfortunately the limits of a single paper are too narrow to discuss principles and to say much about practise, and knowledge of the former should be made more widespread in order that the latter may be appreciated.

The non-botanical public can not be blamed if it receives comparatively worthless productions with greater acclaim than those of value when the former obtain all the publicity and no voice is raised in protest. Exploitations of new plant introductions of little value have certainly been numerous in the past few years. Perhaps this has been a public benefit, for it has increased the general interest in plant breeding and has stimulated many laymen to study the subject in order to be able to separate the wheat from the tares when dealing with new varieties. It is strange, perhaps, with our reputation for always looking for the dollar sign, that the new agricultural productions of greatest economic value have always received less notoriety than the production of horticultural novelties of limited use and small importance; yet such is the case. It is doubtful whether the production of a new field corn that would increase the yield in the United States by ten per cent. would obtain more than a passing notice from the press; yet such an increase would add $100,000,000 per annum to the wealth of

[1] This paper is based on a series of poular lectures delivered at the Bussey Institution of Harvard University April and May, 1910. A second paper will follow.

the country, and the individual who was responsible would deserve to be ranked among the greatest benefactors of the commonwealth.

This illustration serves to show something of the extent of the benefits that may be confidently expected from the improvement of cultivated plants; but the full extent of our rightful expectations is at least ten per cent. increase in both quality and quantity of all the great crops of the United States. In fact this is a very conservative forecast based upon what has been accomplished in the past. Men like Haynes with his "Blue stem" wheat and J. S. Leaming with his "Leaming" corn have perhaps made an even greater percentage increase in the value of the returns from the land upon which their productions have been grown. Their results were obtained largely in the latter half of the last century and even greater advances should be made in the future. This statement is made because, in the last quarter of the nineteenth century, experimental biology was in the same relative position in which chemistry stood in its beginning. During the century chemistry made wonderful advances; during this—the twentieth—century experimental biology will make similar progress. And one of the first and most important applications of the facts discovered will be to guide and direct man in producing new plants and animals by more direct and certain methods.

When one speaks of producing new plants, however, he should not be misunderstood. Man has not yet actually produced new variations (although the time may come when even this is possible); he simply works with the variations which have occurred through natural causes of which little is known. The isolation of a varying plant and from it the production of a variety, or the combination of desirable characters from one strain with other desirable characters from different strains, comprises the total aim and desire of the plant breeder. The idea is simple; to put the idea into practise successfully is often a tedious and difficult task.

As in hybridization the ease with which results can be obtained by selection depends largely upon flower structure. In selection, however, the relative facility with which artificial cross-pollination can be accomplished is of small importance. What one wishes to know is whether cross-pollination or self-pollination takes place naturally. Practically all plants are occasionally cross-fertilized naturally, and many of them have devices whereby they are nearly always crossed; but we are coming to see that cross-fertilization is not as essential to plant life as Darwin endeavored to prove in his "Cross- and Self-fertilization in the Vegetable Kingdom." Wheat, for example, is almost always self-fertilized; yet it has kept its vigor for thousands of years. The importance of this fact to the selectionist is easily seen. If seed from several varieties of wheat is mixed and planted, each variety remains

true to its type because of self-pollination, and during the growing season the plants can be compared and any desirable type selected for future propagation. In a cross-pollinated plant like maize this is not the case. The pollen is carried by the wind through long distances and varieties planted close together are continually intercrossed. The isolation of a particular type is not simple as in the case of wheat, but may be prolonged through many generations. Each prize ear selected for future planting will have had at least a few and possibly many of its seeds fertilized by pollen from less desirable strains. When these seeds are grown they of course again fertilize the seeds of the desirable plants with a frequency proportionate to their number.

In the case just cited recourse may be had to artificial self-pollination. Several hundred seeds are thus produced at one operation and the work of isolating the new variety is made materially easier. But suppose we are dealing with red clover where the flowers are small, almost sterile with their own pollen and produce only one seed. In this crop, the long and tedious method of continuous selection just mentioned must be used, for there is no other way. This method is often called the pedigree-culture method. The main idea of the plan is that the seeds of *single* plants are grown in isolated plots, and the character of the mother plant judged by the characters of the progeny. This method has given much better results than the so-called German method, which consisted in planting a mixed lot of seeds from several of the best plants. For example, the German sugar-beet raisers have for years analyzed large numbers of sugar-beets and have grown their seed from the mother beets showing the highest percentage of sugar. No particular attention was paid to the general average of the progeny of each beet; those were bred from which appeared to be the best as shown by the polariscope sugar test. In this way the amount of sugar produced per acre was gradually increased, but progress was slow and cessation of selection immediately caused the sugar content to decline.

To see the real reason of this we must go back to the time of Darwin. The data from which Darwin proved the doctrine of descent came in large measure from domestic animals and cultivated plants. He saw that plants varied among themselves and that by selection of the variants new types were gradually produced. From these facts he argued that all evolution had taken place by the selection of minute variations and generally through the selective agency of a contest for life taking place among all living organisms. This he called the agency of natural selection. Later, however, Bateson, Korshinsky and de Vries called attention to the fact that many new types of animals and plants are known to have originated suddenly. There was no gradual evolution of the type; it simply appeared fully formed. This hypothesis, called the "mutation theory," found great favor among plant breeders

for they knew that many times they had noticed and isolated plants showing new characters from their cultures, and had carefully made selections for further improvement of the new strain, but that generation after generation showed no further progress. LeCouteur, whom de Vries cites as the first known user of the pedigree culture method, had a case in point. From the heterogeneous lot of wheat plants which he was growing, he isolated a uniform type of great merit which he called "Bellevue de Talavera." For years after, this strain was subjected to selection in order to bring about further improvement, but the efforts were made in vain, for no new heritable variations were produced. Yet something was lacking from this theory. Sometimes there did appear to be a gradual improvement by selection. De Vries said that this was merely a temporary improvement made by selection of quantitative variations. He believed that when selection ceased, sooner or later the improved types would return to the original type of the variety from which it had been produced. The real interpretation of the facts and one which fitted all the parts of the puzzle together, came from the work of Johannsen and later investigators. It is an explanation that should have been thought of before, but like many other important discoveries, it was too simple for ordinary minds to grasp. Weismann had shown years before that the inheritance of characters acquired through outside influences during the development of the body was probably mythical. His investigations led him to believe that there is a continuity between the reproductive or germ cells of different generations, and that the body is nothing but a temporary house built to shelter them. Injuries to the house have no effect on the future generations unless the germ cells themselves are affected. Later Boveri and others, through their cytological studies, showed that the future germ cells are laid down at a very early stage in certain animal organisms and that very few cell divisions take place before the maturation of the reproductive organs and the production of active germ cells. The body cells he found to be built up by continuous cell division of a very different part of the original fertilized egg. Since no biologist, however, had found or is likely to find similar cytological phenomena in plants, no one seemed to grasp the idea that here was the key to the question that had been puzzling the plant breeders. Johannsen, however, brought matters straight by his experiments on beans. He found that commercial varieties of beans, though pure in grosser characters, such as color, were actually very mixed types when such characters as length or weight were studied. Several investigations were undertaken on size characters, the characters most rapidly affected by changes in environment. He found that his commercial variety fluctuated around an average size and that when seeds larger or smaller than this type were selected they responded to it in whichever direction the selection was made. The progeny of the

selected beans were not so extreme, however, as their parents but regressed toward the average character of the parent race. This was nothing new. Galton had discussed the matter a decade before and had interpreted the regression as due to the "pull toward mediocrity" exerted by former ancestors that must have been on the average mediocre. Johannsen was not satisfied with this interpretation and in order to investigate the subject more thoroughly introduced the individual pedigree culture method, or pure line method as he spoke of it, into his work. All of his plants under experiment were self-fertilized for successive generations, so that all of his future bean progeny were descendants of single individuals from the original commercial variety. Each pure line he found to fluctuate around a typical size just as the commercial variety had done. Some types were exactly the same as the original mixed type, but others fluctuated around averages that would have been considered more or less extreme variations in the original. He then grew extreme variants from each of his pure lines and made the discovery that no progress at all was made by repeated selections of this kind. The progeny of the high extremes and the progeny of the low extremes each were found to fluctuate around the same pure line average. It was quite evident then that in the first place he had been dealing with a mixed race. This mixture consisted of sub-races each with a heritable difference in the character size. These heritable variations, however, were obscured by size fluctuations produced by differences in moisture, sunlight and fertilizer received by the different individual plants. There was even a difference in the size of individual beans on the same plant, due probably to location of some pods in places on the plant more desirable than others for the utilization of the plant's soluble foods waiting to be stored in the seeds. *These differences due to immediate environment were not inherited.* They behaved exactly as the acquired characters of an animal. This made the rôle of selection clear. The only improvement that selection can achieve is to isolate a substrain if such a substrain or substrains exist in the variety under experiment. When this substrain has been isolated, selection has absolutely no effect, and even if continued for countless generations will have no effect until nature produces one of the heritable changes which are so much rarer than the fluctuations produced by environment. It is also evident that the older idea that improvements made by continued selection—*i. e.,* gradual isolation of a type—are inconstant, is wrong. The explanation is that since non-inherited fluctuations obscure the heritable variations, only a pure line method can absolutely isolate a pure strain; and in the German method of mass selection with poor control against mediocre pollen, the chances were overwhelmingly in favor of the selected type recrossing with the more commonly cultivated and poorer type from which it came.

To my mind this work should clear up the strife between the critics and the adherents of evolution by mutation. It is evident that there are variations that are inherited and variations that are not inherited. If we call the one a mutation and the other a fluctuation, we have a distinction that will stand analysis. Why should a further distinction be made? De Vries believes mutations to be qualitative, fluctuations quantitative. Nevertheless, quantitative changes that are transmissible occur in much greater numbers than do qualitative changes. Opponents of mutation believe wide jumps appear too seldom to have been a factor in organic evolution, but they can not deny that they do occur. There are too many authentic cases in variation under domestication. Yet no one who has had experience in breeding plants will deny that small variations (not fluctuations) occur with much greater frequency. While it is impossible to prove it, I believe that the mathematical law of error controls the transmissible variations as well as fluctuations. If one could collect a random sample of variations that are inherited he would probably find that a great many forces act as the causes, and therefore as in ordinary probability, the extreme changes—that is, the great variations—occur with less frequency. One should remember, however, that in our present state of physiological knowledge, he can not know with much certainty which of two changes that apparently differ greatly in magnitude is really the greater in the light of the plant's economy.

It might be well before leaving this part of the subject to speak of one other point. In a strain that has been self-fertilized for several generations, gradual progress has sometimes been made by selection. This probably comes about because the parent plant is still hybrid in regard to certain characters, and it is to their recombinations that the intensification or reduction of certain apparently single characters but which are really combinations of separately heritable characters, is due. According to the law of chance with repeated self-fertilizations any strain approaches a constant condition in all of its characters when unselected, but one can not say when this state is reached unless he knows the exact number of hybrid characters in the beginning and can recognize each.

If we were to take up the crops of the United States which owe their present excellence and future prospects in large measure to the isolation of superior strains by selection, we should cover a great majority of the agricultural wealth of the country. Of course natural cross-fertilization and even occasional artificial hybridization have played important parts by causing recombinations of characters, but selection has been the main cause of improvement. Two of the important crops, tobacco and wheat, are very seldom cross-pollinated naturally; nevertheless new types are continually appearing in the fields. To make new varieties

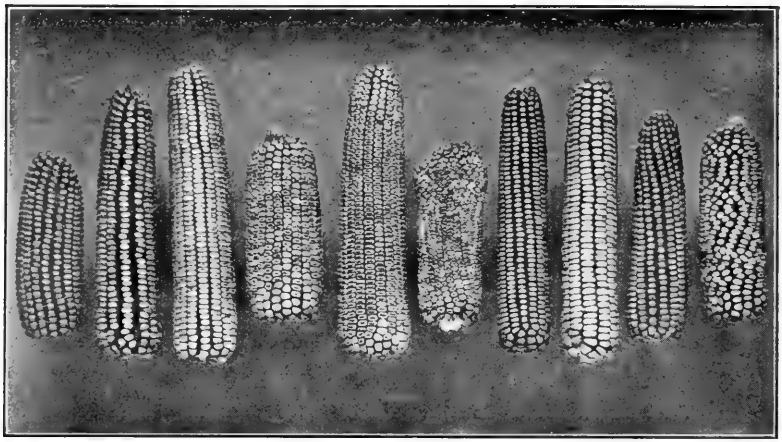


FIG. 1. TYPES APPEARING IN A SINGLE FIELD OF MAIZE. A strain like the ear near the center has been isolated.

it simply takes an alert eye for their detection, comparative tests to prove their merit and the time needed to produce a sufficient increase for commercial use. Some of our other important grain crops like oats and rye are more often cross-pollinated, as is also our chief grass crop, timothy. But as maize is probably the most difficult crop to deal with, and is a typical cross-pollinated plant as well as our most important cereal, perhaps it will be of interest to take a short survey of some of the problems with which one has to deal when endeavoring to improve it by selection.

Maize is the only one of our cereals that is monœcious. The tassel contains the pollen or male element while the silks are the stigmas of the female flowers. In order that the pollination of the silks shall be relatively certain, each tassel produces about thirty million pollen grains; and as the ears average less than five hundred seeds apiece, there are about sixty thousand pollen grains produced for each kernel. With such a large amount of superfluous pollen floating around in the air, there is a great deal of inter-crossing between the neighboring plants. This fact has been an obstacle to the improvement of maize, but it has been offset by one advantage it possesses over the other cereals, that of producing large ears. Since each individual ear must be handled and its characters noted at husking time, it is not strange that ears with desirable variations sufficiently striking to catch the eye of the grower have become the parents of numerous distinct varieties. By selecting desirable seed ears and isolating them from other varieties, various strains have been produced that are remarkably uniform in characters such as color that have forcibly attracted the attention of the breeder. Even in these strains, however, there are many natural types growing side by side and continually crossing with each other. There are stalks

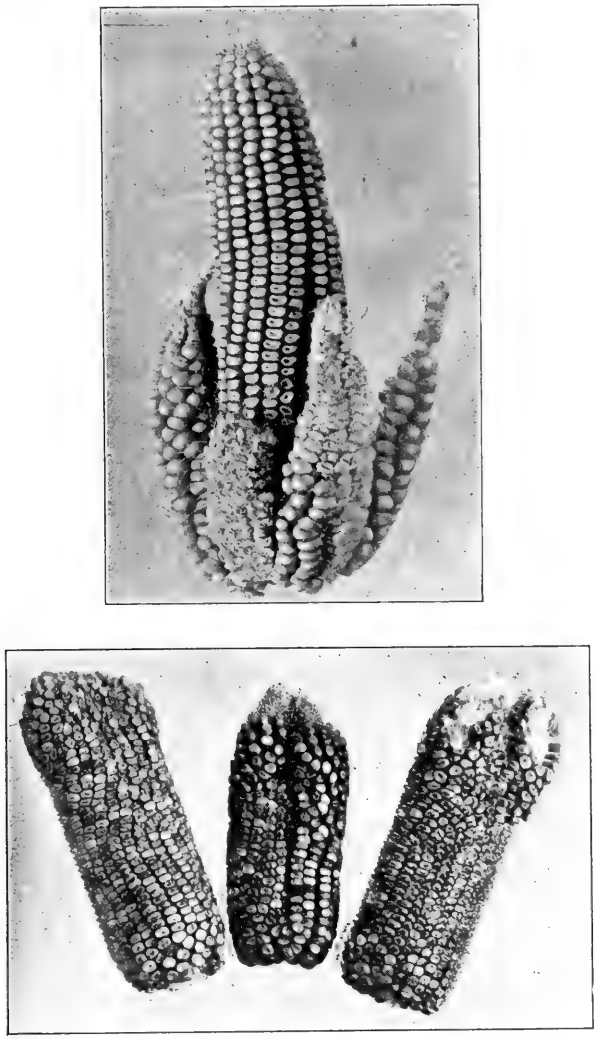


FIG. 2. INHERITED ABNORMALITIES APPEARING IN MAIZE. All pollen from these plants and from their normal sister plants must be prevented from maturing.

which bear their ears high and stalks which bear them low, stalks with long and stalks with short ear shanks, stalks with different leaf markings and with notably different tendencies to produce suckers. Differences are everywhere present even in the ears, as is shown in the accompanying photograph (Fig. 1). A large number of these differences are simply fluctuations produced by the environment and are not inherited. The obscuration of heritable variations by the fluctuations and the mixed condition of the natural types makes it a difficult task to isolate the most productive types. Many variations of technique have been proposed

for the prosecution of the work, but are all based upon the idea of proving the capacity of a mother ear by the characters of the progeny produced. If a very large number of ears are included in the original stock, it is unquestionable that some of them will transmit more desirable characters than others. It only remains to test them out by growing the seed of each ear in marked plots or rows and gradually eliminating the undesirable types.

The accompanying diagrams, showing the work of the Illinois Agricultural Experiment Station in their experiments in selecting for high and low protein content, and high and low oil content, admirably illustrate the rapidity with which progress can be made by selecting only from the maternal side, even in the face of constant intercrossing. This work the writer believes has given a com-

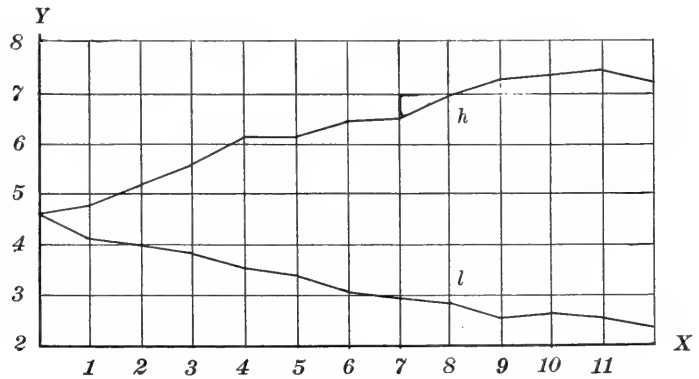


FIG. 3. DIAGRAMMATIC REPRESENTATION OF THE RESULTS OF THE ILLINOIS AGRICULTURAL EXPERIMENT STATION in selecting for high and for low protein content. *Y*, per cent. protein in crop; *X*, generations; *h*, high protein strain; *l*, low protein strain.

plete corroboration of Johannsen's conclusions on pure lines. This interpretation has been made, however, from their published data, and the Illinois station should not be held responsible. This work of breeding to change the composition of maize was started in 1896 with a hazy Darwinian idea that as corn was known to vary in composition, continuous selection of extreme variations would produce a continuous change in type. A very old type—Burr's White—furnished the foundation stock. A chemical analysis was made of parts of the individual ears each year, and the extreme ears planted. From the first, the four lines above mentioned were planted in isolated plots and were continually selected in the same direction. After ten generations the average crop of the high protein line had reached 14.26 per cent., while the low protein line was only 8.64 per cent.; the high oil strain had reached 7.37 per cent., while the low oil strain was reduced to 2.66 per cent. These facts clearly show the rapidity with which results can be obtained

by this method of selection even with a crop that is often cross-fertilized. But the diagrams show other facts. The published records show that the variability of the race was but little, if any, reduced by continuous selection. With extreme variants comparatively as far removed from each year's type, available for planting in each successive generation, the gain each year should have been at the same rate, if the Darwinian interpretation of the rôle of selection were correct. On the contrary, we notice that the regular curve fitted to the crop averages for ten generations, is first concave showing great progress made by selection, is later convex as progress becomes slower, and last becomes horizontal

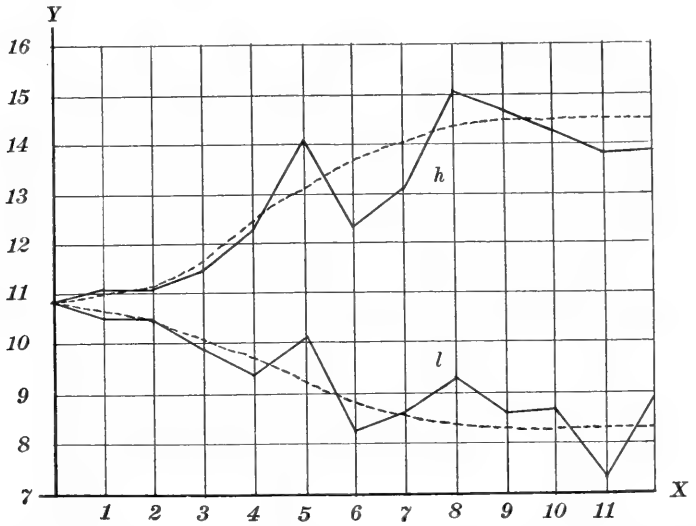


FIG. 4. DIAGRAMMATIC REPRESENTATION OF THE RESULTS OF THE ILLINOIS AGRICULTURAL EXPERIMENT STATION in selecting for high and for low oil content. *Y*, per cent. oil in crop; *X*, generations; *h*, high oil strain; *l*, low oil strain.

as no more progress results. It is very evident that the original stock was a mixed race containing sub-races of various composition intermingled by hybridization. Selection rapidly isolated these sub-races. The isolation was practically complete at the eighth generation in the case of the protein strains and the ninth generation in the oil strains. After this selection accomplished nothing. That the effect of selection was simply the isolation of a sub-race and not a continuous response, is further demonstrated by the fact that in 1903 another plot was started with seed from the isolated high oil strain. After four years' cessation of selection, the average composition of the crop remained the same, showing that after complete isolation of a homogeneous type no retrogression of the selected character occurs unless intercrossing with mediocre strains takes place. Fluctuation in composition still appears, but this is the non-inherited kind produced by external conditions.

It is sometimes somewhat difficult to see why selection of this kind should yield results slowly. There are indeed many points concerning which little is known. One may picture to himself, however, that where crossing is always likely to occur and where the apparent character is in reality a combination of a number of separately inherited characters, many thousands or even millions of individuals would have to be grown to run a fair chance of obtaining the most desirable combination. By growing a few individuals in which the desired character is intensified in successive generations, the combination wanted may be obtained with the use of smaller numbers.

I have stated that nothing can be accomplished by selection after a pure line or genotype as Johannsen calls them is isolated, unless a new transmissible variation is produced by nature. The questions then arise: how often may such changes be expected? and, what is their nature? Such changes are of two kinds,[2] progressive where a new character appears, or retrogressive where a character is lost. But little can be said as to their relative frequency. Undoubtedly some species are in a more unstable condition than others and give more of such variations, as de Vries has already suggested. On the other hand, certain unknown combinations of external conditions may favor germ-cell changes. They are both rare, the progressive changes being relatively much less frequent than the retrogressive changes, but they are sufficiently common for several to have come within the knowledge of every experienced breeder.

There is another type of variation much more closely related to changes occurring in "pure lines" than is generally supposed. I refer to what is commonly known as bud variation or vegetative sports. Retrogressive variations of this kind are probably no rarer than the same kind of changes occurring in pure lines. No authentic progressive variations (as distinguished from digressive) are known. In my own experience in growing eight hundred species and varieties of tuberous solanums (largely potato varieties), fifteen retrogressive variations have been noticed, and the changes that occurred were exactly like those occurring in seed-propagated strains.

The relative value of progressive and retrogressive variations is difficult to estimate. In organic evolution the former must have been far more valuable; commercially the latter are often of great worth. We may cite, for example, the great value of the bush or dwarf varieties of beans, peas and tomatoes that have originated as retrogressions.

[2] De Vries also gives a third kind, digressive variations, such as occur when a character previously possessed by but latent in the plant appears. This class is unnecessary. Digressive characters appear either through the loss of a complementary inhibiting factor or the gain of a complementary factor necessary for it to become active.

In closing I should like to call attention to a fact both of evolutionary and of commercial importance. The first generation of crosses between nearly related types generally grows more vigorously than the pure types themselves. If the fertility is not impaired, they even fruit more freely. This is undoubtedly the explanation of Burbank's quick-growing hybrid walnuts, but if they were self-pollinated and grown for another generation a large percentage of the progeny would lose this character. In naturally self-pollinated types like tobacco, one sees the phenomenon expressed as greater vigor in a cross; in a continually intercrossed species like maize the same thing is shown by a loss of vigor when the plants are self-pollinated. It is clear then that if pure strains of maize are gradually isolated by selection, by the same token they lose in vigor and productiveness. The original mixed strain may contain

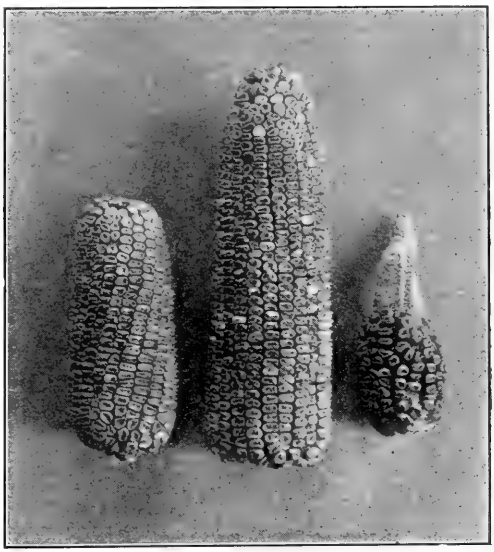


FIG 5. EFFECTS OF INBREEDING IN MAIZE. Outer ears inbred four generations. Middle ear the result of their crossing, first generation.

sub-strains some of which are much more productive than others. The less productive types may be discarded, but at the same time there is a loss of vigor from the fact that they are withdrawn from hybrid combinations. The logical procedure, then, is to isolate two high-yielding types, combine them by hybridization, and grow only the first generation of the cross. This is not mere theory, for by using such methods I have obtained from 100 to 200 bushels of shelled corn per acre on small plots. Unfortunately, this method can not be used to advantage on many crops, but in the case of maize the procedure is simple. There are many breeders using the isolation method of improvement. From

FIG. 6. RESULTS OF CROSSING TWO INBRED STRAINS OF MAIZE. At the right average of the parents after three generations inbreeding, 61 bushels per acre. At the left crop of first generation cross of the inbred strains, 101 bushels per acre.

them the grower obtains two strains and plants them in alternate rows. At flowering time all of the male flowers or tassels are removed from *one* of the plants of the varieties before they shed their pollen. All the ears that these plants produce are crossed with the other variety. It is this seed that produces the vigorous plants.

This method might be made the basis for some very valuable work in forestry. It is quite conceivable that many important timber trees might be found where nearly related species or varieties would cross readily. Experiment would show how great an increase in rapidity of growth could be expected, and whether such an increase would pay for the increased expense of hand hybridized seed.

FIG. 7. SILVER HILL. Normal at left. Bud variation isolated by selection at the right.

One may summarize by saying that two important points cover the whole rôle of selection. The first point is that nature continually causes variations to appear in plants. The majority of these variations are simply accelerations or retardations of development of the whole or of certain parts of the plant due to good or bad environment at critical stages of the plant's growth. These variations are not inherited because the reproductive or germ cells are not affected. Other variations, however, are being constantly produced by nature—though much more rarely—which do affect the reproductive cells and are transmitted to the plant's progeny. These variations are the basis of selection. They are constant from the beginning and remain so unless changed by a second variation affecting the same constituent in the reproductive cells that is due to develop the character in question.

The second point to be remembered is that the whole aim and action of selection is to detect the desired heritable variants among the useful commercial plants and through them to isolate a race with the desired characters. When this is accomplished, selection can then do nothing until nature steps in and produces another desirable variation.

In other words, the results of selection are not continuous. Selection does not gradually perfect a character. The production of heritable variations is intermittent and the intermissions may be long. If the practical results seem to be parts of a continuous process, it is because of the imperfect methods at hand to isolate the desirable variations from their combinations with undesirable characters formed by natural hybridization.

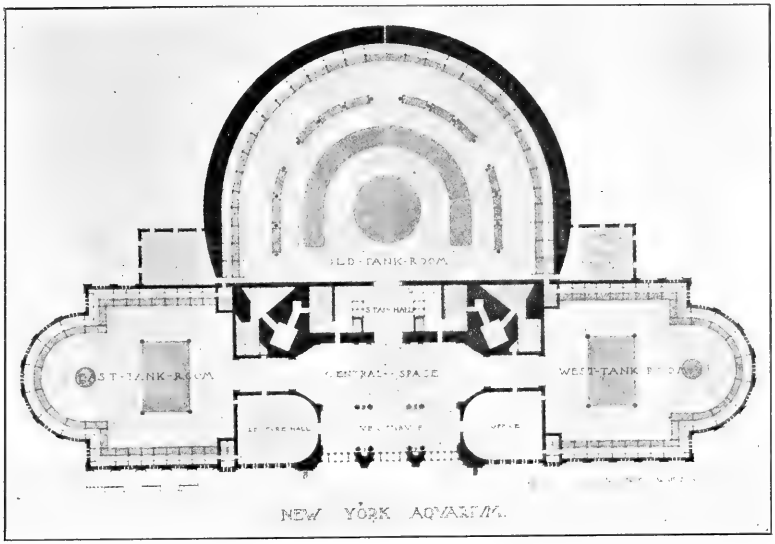
THE PROGRESS OF SCIENCE

THE WORK OF THE NEW YORK ZOOLOGICAL SOCIETY

THE Zoological Society has performed an important service for the city of New York by the establishment and conduct of a Zoological Park and later by taking charge of the Aquarium. The relations of the society to the city are similar to those of the trustees of the American Museum of Natural History, of the Metropolitan Museum of Art and the Botanical Garden, but are somewhat unusual. In each case the city provides the buildings and the cost of maintenance, while a private corporation supplies the collections and is responsible for the conduct of the institution. The plan appears to have worked very well, as each institution has had a strong organization, free from any political control, but effective in obtaining large appropriations from the city and considerable private gifts.

The fourteenth annual report of the Zoological Society lays emphasis on increasing the scientific work done both at the park and the aquarium. The institutions have been extremely successful in gathering and maintaining large collections of animals and interesting the public in them; but they have not as yet been able to undertake research work comparable in value. The director of the aquarium writes in his report, "The small aquarium at Naples has made Naples famous." It is not, however, the exhibition tanks, but the research work and publications of the station which have added to the fame of Naples. The entertainment and instruction of the public is an important function for the city to undertake, and the money devoted to these purposes at the Zoological Park and the Aquarium is well spent. But money used for research is not spent at all; it is invested for the permanent benefit of all the people. Zoological gardens have hitherto emphasized scientific work less than have botanical gardens, but there are problems of comparative psychology and comparative pathology to which collections of

THE ADMINISTRATION BUILDING OF THE NEW YORK ZOOLOGICAL SOCIETY.



PRELIMINARY PLAN FOR THE ENLARGEMENT OF THE NEW YORK AQUARIUM.

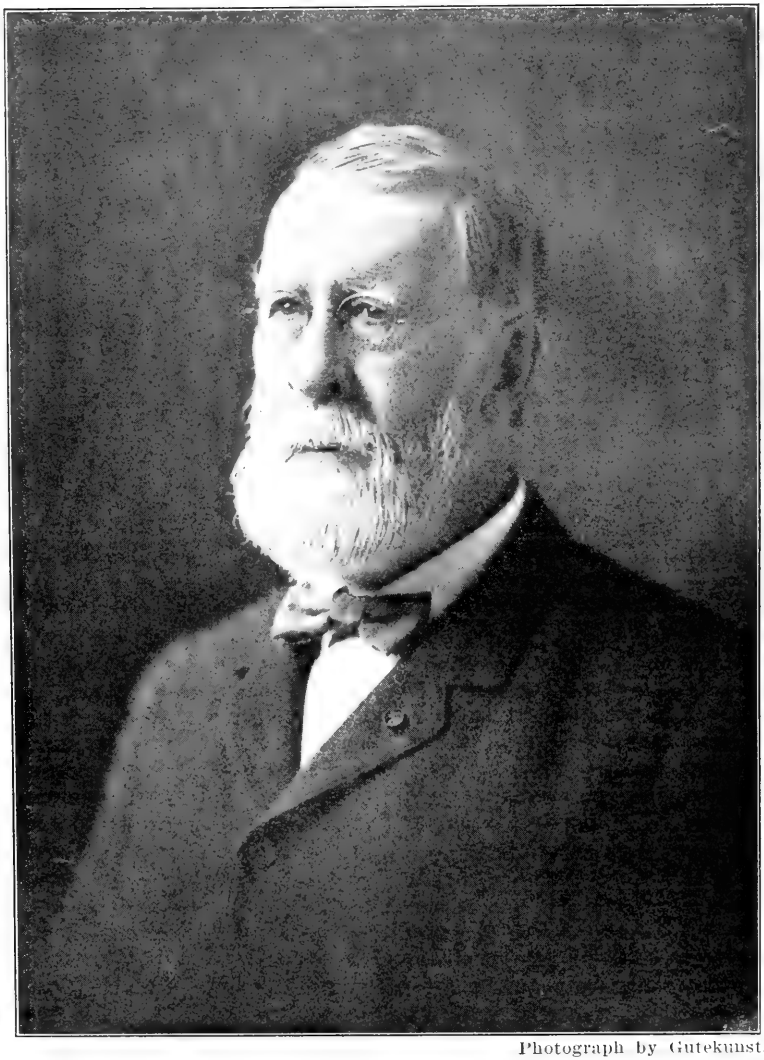
animals might be made to lend themselves admirably; and there are many kinds of research work in experimental morphology and heredity which might be carried on to advantage. While paying their cost in exhibits of general interest and unusual instructiveness to the public, they would at the same time advance science and its applications.

The report of the executive committee begins with the paragraph: "With this year closes the first period of the Zoological Park development, and from now on the work of the society will be, to an ever increasing degree, in the direction of the remaining objects of the society. Briefly stated, those objects are, scientific work in connection with the collections, and the protection and preservation of our native fauna." The director of the aquarium also urges the desirability of establishing a small staff of scientific curators. We may consequently expect that in a short time the contributions to science from the Zoological Park and the Aquarium will rival those from the Museum of Natural History and the Botanical Garden.

The director of the Zoological Park urges the need of additional bear dens, a zebra house and an aviary for eagles and vultures. He expresses the hope that these three buildings may be obtained during the present year and states that with these the animal buildings and other installations for exhibits will be practically complete. During the past year an administration building has been erected at a cost of $75 000. It is intended for executive offices and as a meeting place for the members, and is to contain a library and art gallery. At present a collection of some 600 heads and horns, in which the director has taken much interest, is housed in this building, but a separate building open to the public is planned.

The attendance at the park last year was 1,614,953, an increase of 200,000 over the preceding year. There were 5,000 animals on exhibition representing 1,117 species, of which 812 were mammals, 2,880 birds and 1,308 reptiles. This is an increase over 1908 of 155 species and 421 specimens, including many of special interest.

The attendance at the aquarium reached the remarkable record of 3,-



Photograph by Gutekunst.

GEORGE FREDERICK BARKER.

803,501, an increase of a million and a quarter in a single year, and probably a larger number of persons than visited any other institution in the world for scientific entertainment and instruction. There were no increases in the collections, as there is no room for them. The director very properly urges the desirability of enlarging the aquarium and providing laboratories for scientific work and men to carry it forward.

DEATHS AMONG AMERICAN MEN OF SCIENCE

SINCE the death of Mr. Alexander Agassiz, in April, we have lost three other American scientific men officially placed among the hundred who are most eminent by their membership in the National Academy of Sciences. They are Professor George Frederick Barker, General Cyrus Ballou Comstock and Dr. Charles Abiathar White.

Professor Barker, who was both a

CHARLES ABIATHAR WHITE.

chemist and a physicist, was born in 1835 and graduated from Yale in 1858 and later in medicine from the Albany Medical School. He held various positions, including the chair of physiological chemistry at Yale until 1873, when he became professor of physics at the University of Pennsylvania, and for thirty-seven years, latterly as professor emeritus, held a leading position in the university, when Philadelphia had a more dominant position in science than it has been able to maintain. Professor Barker was an admirable lecturer and the author of widely-used text-books of chemistry and physics; he served as expert in important legal cases and carried forward research work of consequence. He was elected to the National Academy in 1876 and was president of the American Association for the Advancement of Science in 1879.

General Comstock, born in 1831, graduated from West Point in 1855 and taught physics in the academy.

He was actively engaged in the civil war, first in the defenses of Washington and later as chief engineer and senior aide-de-camp to General Grant. Later he became superintendent of the geodetic survey of the great lakes and of the improvements at the mouth of the Mississippi, and published works on these and other engineering topics. He was elected to the National Academy in 1884, and in 1907 gave the academy a fund of $10,000 for the promotion of researches in electricity magnetism and radian energy.

Charles Abiathar White, born in 1826, though early interested in science, was late in beginning professorial work. He received a degree in medicine at the age of thirty-seven and three years later became state geologist of Iowa and professor of natural history in the state university. He accepted a chair in Bowdoin College in 1873 and two years later became geologist in the surveys of Powell and Hayden. For many years he was connected with the Geological Survey, the National Museum and the Smithsonian Institution. He was elected to the National Academy in 1889. He published over two hundred contributions to geology, zoology and botany, maintaining his scientific activity to the end, as is indicated by an article in a recent volume of this journal.

Mr. Agassiz and Professor Barker died at the age of seventy-five, General Constock at the age of seventy-nine, Dr. White at the age of eighty-five. Another American scientific man who played an important part during the second half of the last century and died with his life work fully accomplished was Professor William Phipps Blake. He was born in 1826 and made valuable studies in the mineral deposits and geological structure of the Rocky Mountain and Pacific coast regions. Dr. Amos Emerson Dolbear, for thirty-six years professor of physics at Tufts College, known for inventions and other work in physical science, has died at the age of seventy-three years. Professor Robert Parr Whitfield, of the American Museum of Natural History, eminent as a geologist, has died at the age of eighty-two years. Dr. Cyrus Thomas, archeologist in the Bureau of American Ethnology since 1882, well known for his contributions to anthropology, has died at the age of eighty-five years.

More grievous than the death of veteran men of science is the loss of those whose work is not accomplished. Charles Reid Barnes, professor of plant pathology in the University of Chicago, dying after a fall at the age of fifty-two, was among our leaders in botany in both performance and promise. Dr. H. T. Ricketts, also of the University of Chicago, but called to the University of Pennsylvania, died in Mexico City at the age of thirty-nine years from typhus fever contracted as a result of research work on that disease. Even this partial list shows how severe have been the losses by death from among American men of science during the past six months.

SCIENTIFIC ITEMS

THE Paris Academy of Sciences has conferred the Janssen Prize, consisting of a gold medal, on Director W. W. Campbell, of the Lick Observatory.— Professor Theodore W. Richards, of Harvard University, has been invited by the Chemical Society (London) to deliver the next Faraday lecture. This will be the tenth Faraday lecture, the others having been given as follows: Dumas, 1869; Cannizzaro, 1872; Hofmann, 1875; Wurtz, 1879; Helmholtz, 1881; Mendeléef, 1889; Rayleigh, 1895; Ostwald, 1904; Emil Fischer, 1907.— Dr. John Benjamin Murphy, professor of surgery in Northwestern University, has been elected president of the American Medical Association, for the meeting to be held next year at Los Angeles.

THE
POPULAR SCIENCE
MONTHLY.

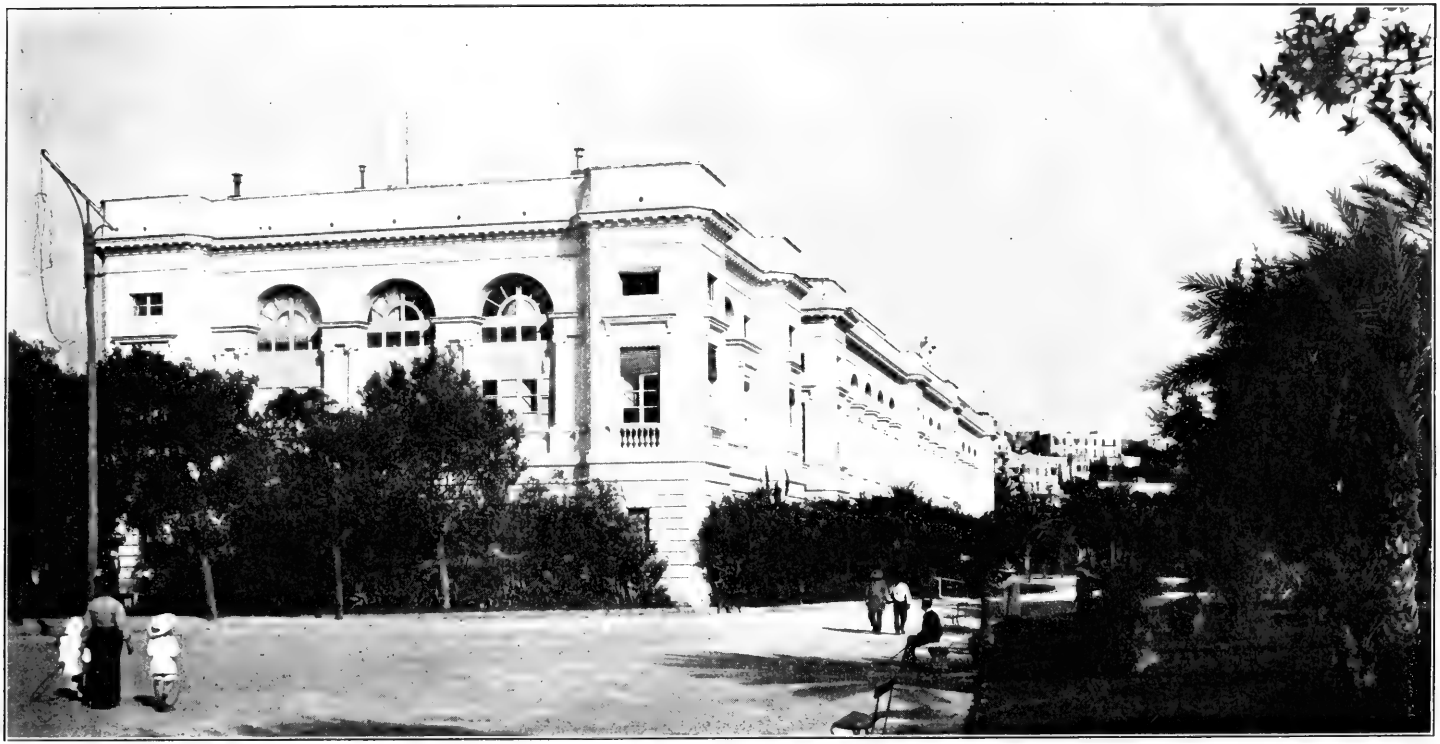
SEPTEMBER, 1910

THE ZOOLOGICAL STATION AT NAPLES

By Professor CHARLES LINCOLN EDWARDS

TWENTY centuries ago the rain of ashes and pumice-stone from Vesuvius buried Pompeii, and, at the same time, a stream of mud sealed up Herculaneum. Within the period of the last three hundred years, four times in succession, Torre del Greco has been covered by the flowing lava, but each time this town has been rebuilt. The great lava-stream of the eruption of 1906, lying just beyond Torre Annunziata, is an ominous demonstration of the evil possibilities still within old Vesuvius. To-day the small white cloud of smoke above the summit of the volcanic ash-cone merely hints of these latent forces that may again overwhelm some community at the base, while now the great mountain rests in its beauty and historic interest, overlooking the blue waters of the Bay of Naples. To the right are the massive buildings of the city intersected by narrow passage-ways, all crowded between the shore and the high wall of the hills which stretch from the Pallazzo Capodimonte to the Posilipo. Far away at either side of the Bocca Grande are the islands of Capri and Ischia, at times clearly outlined, or again almost lost in the haze of opalescent mist.

All through the day many groups of fishing-boats are scattered about the bay while the men cast and haul their nets. Over the stone sea-wall others pull on the end-ropes of a drag-net that has been set far from shore, until at last the great burden of fish is safely unmeshed. Here and there divers go down to scrape the rocks and sand of the bottom for mussels which are placed in a bag worn at the waist. From an anchored skiff a man dredges with a scoop-net attached to a long pole contented with many of the living things that appear, for strange creatures are welcome in the Neapolitan market. Thus, without planting or cultivating, the people gather from the sea an unending harvest. But from under the cliff of Sorento, to the wave-eroded rocks of Ischia,



View of the Zoological Station from the West.

whenever a fisherman finds a strange or curious creature he carefully brings it to the zoological station, sure of ready purchase in an institution that uses every agency for the advancement of the knowledge of the life of the sea.

The opening of the zoological station in 1874, realized the dream of Anton Dohrn of a laboratory for marine biological investigation, and now, in the high development of this institution, we mourn the death of its creator, which occurred on the twenty-sixth of September, 1909. Dohrn himself tells in an article in the *Preuszische Jahrbücher* for 1872, how, during his travels to various European coasts, the necessity was impressed upon him for the erection of marine laboratories suitably equipped for research. In October, 1868, after a journey to Scotland rendered disappointing by bad weather, Dohrn sought the rich faunal region of lower Italy and Sicily where Johannes Müller and his students had been pioneers in marine zoology. Fully realizing that such an institution as he planned does not spring into being completely formed by *generatio æquivoca,* but rather develops like an organism, Dohrn began to collect money for the erection in Messina of a building which should contain rooms for investigation and also an aquarium for the entertainment of the public. The next step, in January, 1870, was to change the plan so as to locate in Naples where the larger numbers of tourists and citizens would justify a great aquarium, not only for popular education but as a substantial aid in support of the scientific work of the institution. In the *Deutsche Rundschau* for 1892, Dohrn tells the story of the preliminary work necessary to enlist the interest and support of the Prussian ministry and the government of Naples. Overcoming difficulties and interferences that would have utterly discouraged a less enthusiastic and steadfast nature and valiantly taking his patriotic part in the Franco-Prussian war, it was not until June, 1872, that a contract with the city authorities was executed for the erection by Dr. Dohrn of a building for the zoological station. The original contract has since been modified, so that now the station occupies 4,000 square meters of ground in the Villa Nazionale and is to remain in the possession of the Dohrn family for ninety years, then reverting to the city of Naples, unless otherwise provided for.

While devoting his own life and his estate to the building up of a great central station for marine biology in Naples, Dohrn urged the necessity for similar stations in all lands, to release investigators from the troubles and expenses otherwise involved. These advantages he especially desired for the young men fresh from the university, who might thus increase their powers, widen their knowledge and enlarge their general point of view. If it be possible to remain free from the pressing necessities of life for four or five years, such a young man could demonstrate whether he really had the call to be an investigator. The work would necessitate the wearisome uncovering of the smallest

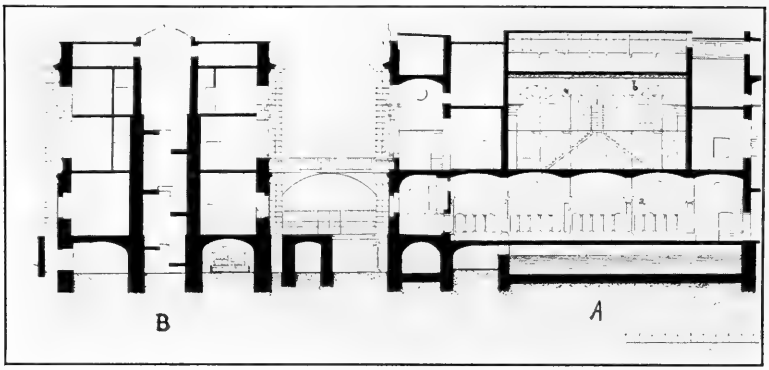
Prof Dr Anton Dohrn

facts, together with the placing of large problems before the mind for imagination and criticism to solve. An enthusiast for Darwinism and influenced by the philosophical writings of Leuckart and Milne-Edwards, from the very beginning, Dohrn's conception of the field of work broadly included the investigation of function as well as form, and the phylogeny of both. The dissection of animals, the study of their tissues by the aid of the microscope and the description of their life histories from the fertilized egg through all the changing embryonic and larval stages, should be reinforced by physiological experiment and chemical analysis, together with the observation of the manner of living and behavior of the animals.

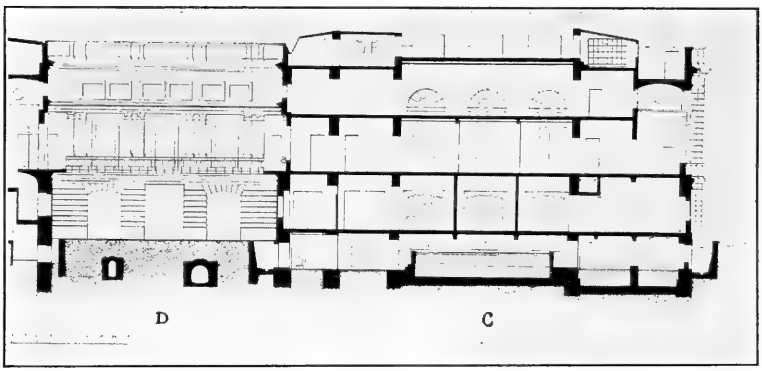
The zoological station is situated on the shore of the bay in the Villa Nazionale, on the most beautiful and convenient site in Naples. One approaches by a long walk flanked by rows of stone-oaks whose overarching, intertwining branches produce a grateful shade from the brilliant sunshine. Here and there groups of phœnix palms, spreading, leafy palmettos and cycads, add the appropriate subtropical vegetation. The renaissance architecture is perfectly adapted to the uses of the station, while the beautiful structure fits into the scene as naturally as the palms themselves.

The oldest of the three buildings (*A*) of the zoological station was opened in 1874 and is now chiefly occupied by the public aquarium (*a*) and the library (*b*). The second building (*B*), finished in 1886, is connected to the western end of the first by bridges and contains the department for collecting and preserving organisms as well as individual laboratories for zoologists. The third addition (*C*) was built in 1906 for the new science of comparative physiology. This laboratory lies to the east of the aquarium, being connected therewith by a building (*D*) surrounding a court. It is scarcely necessary to enumerate the rooms and describe them in detail. In fact no one at the station could tell me just how many rooms there are! It is sufficient that each investigator is provided with a laboratory containing large and small aquaria, tables, and all necessary reagents and apparatus for his work. There are also large general laboratories for zoology, physiology, botany and chemistry, with all the equipment necessary for research. The museum, now under charge of Dr. Gast, contains a faunal series of specimens so wonderfully preserved that often they are more beautifully expanded than the living animals themselves.

From the brilliant sunlight one enters the semi-obscurity of the large aquarium hall. Great tanks, with plate-glass fronts, are around the sides of the room, and a double row in the middle partially divides the hall. The only light enters through the water, so that one has the impression of being in a submarine environment. The sea-water is stored in large tanks upon the upper floor, then, mixed with air, circu-



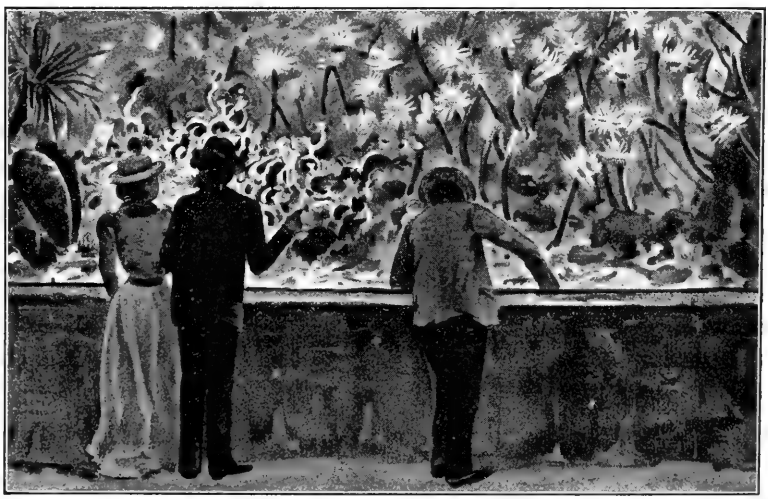
SECTIONAL PLAN OF THE FIRST TWO BUILDINGS OF THE ZOOLOGICAL STATION. *A*, building containing (*a*) aquarium and (*b*) library; *B*, individual laboratories.



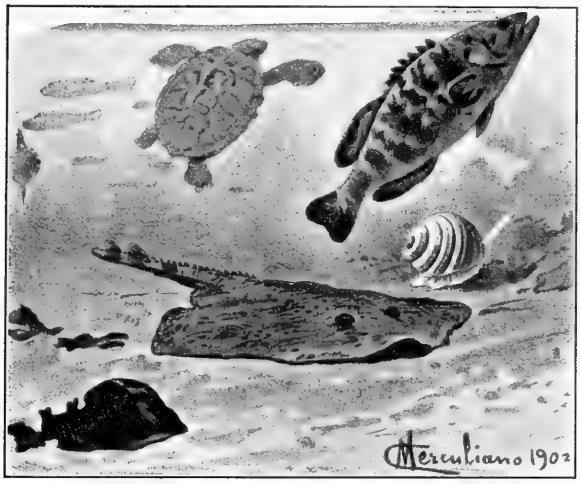
SECTIONAL PLAN OF THE LABORATORY FOR COMPARATIVE PHYSIOLOGY (*C*) AND CONNECTING BUILDING AROUND THE COURT.

lates through the aquaria and finally runs into a sand-filter in the basement to be again pumped into the upper tanks. Every fourteen days a fresh supply is pumped in from the sea. A perfectly developed system of collecting enables the institution to exhibit the most beautiful and interesting animals of the bay of Naples in large numbers and in the best condition. A little book published in Italian, German, French and English gives, in simple language, just such a description of the animals, their habitat and behavior, as will appeal to the public. There are many "happy families" formed upon long observation of the different kinds of animals that may live together without acquiring too marked a taste for one another. The aquarium containing the coral animals is constructed like a grotto under the arch of which one sees the orange-colored polyps spread about like marigolds. Some of the related anemones are actually old, as is shown by their long, wrinkled, thick-skinned bodies, but their straight, or slightly curled tentacles of purple, or lavender, or cream-color, or brown, are most beautiful.

Among the echinoderms the methods of feeding are interesting. The sea-cucumber holds fast to a rock by means of the suckers at the tips of its tube-feet, and, with tentacles widely expanded like the branches of a tree, waits for minute crustaceans and the larvæ of all sorts of animals to comfortably settle themselves upon the hospitable branches. Then, with the least possible motion, the sea-cucumber very gradually bends a tentacle over and into the mouth, and, as it is again extended one of the two small tentacles scrapes off the resting organisms. So each tentacle, in rhythmical succession, takes its turn in the feeding process. Some species of star-fishes have large mouths and can swallow snails and mussels whole, sometimes consuming as many as twenty-five or thirty mollusks of various kinds at one meal. Other star-fishes have mouths too small to receive the animals commensurate with their appetites and so they simply turn their stomachs inside out, covering over a clump of oysters, and thus forming a sort of external stomach into which the secretion from the digestive glands is poured. When the soft parts are thus dissolved and absorbed the star-fish pulls in its stomach and goes on in its devastating course. The sea-urchin has an apparatus known as Aristotle's lantern providing five strong teeth worked by powerful muscles with which it catches live worms and crabs. The sea-crawfishes, built like lobsters except for the absence of the large pincers, most perfectly convey the impression of life on the bottom of the sea. They seem like uncanny agents of evil as they solemnly stalk about over the rocks, poking their great antennae into each other's affairs and always having several claws out for a fight, yet seldom engaging with one another. Some of the veterans, however, have lost an antenna, or a leg, and the missing parts are being regen-



THE PALM-LIKE RINGED WORMS.

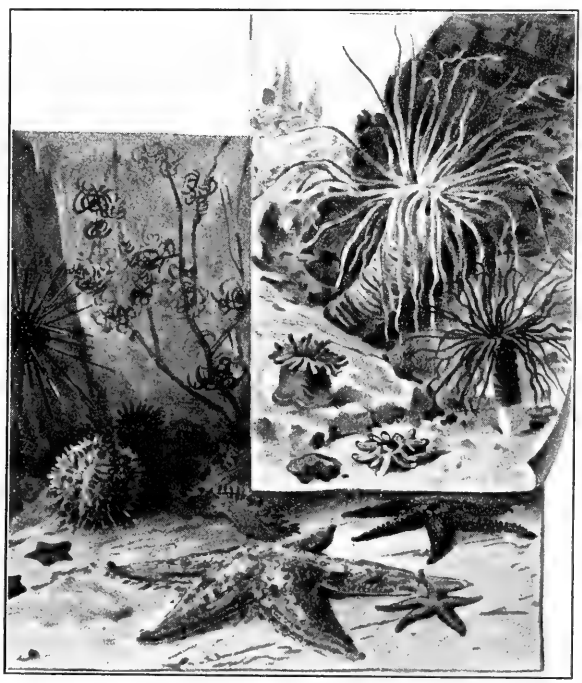


ONE OF THE HAPPY FAMILIES IN THE AQUARIUM.

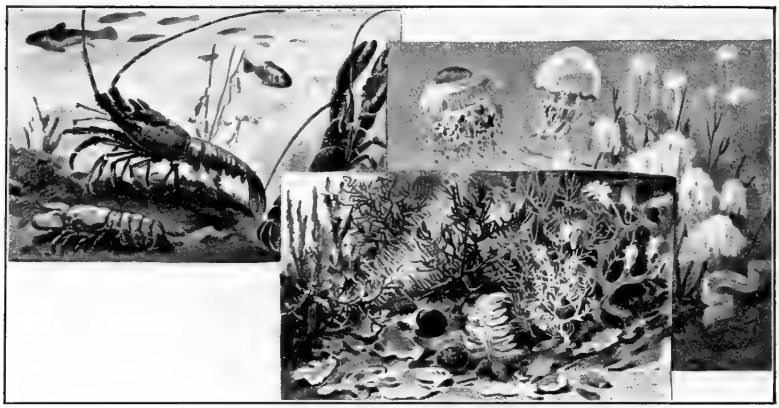
erated. The semi-transparent squids, with posterior triangular fins, swim back and forth as delicately poised as submarine monoplanes. When a live fish is placed in the water the squid darts at it, grasps it firmly with the suckers or the tentacles and cuts off the head, eating only the body. The cuttlefish, with broader body, striped like a zebra, and big elephantine head, constantly undulates a fin-like fringe around the border of its mantle, as it nervously drifts here and there. Frequently it wriggles into the sand which it throws upon its back, or, if much disturbed, ejects a cloud of ink in which it disappears. The large octopus has a body that suggests both a toad and a spider, with highly developed eyes and brain projecting above it. Generally this devil-fish lies sleeping in a corner of the rocks, or lazily reaching out and creeping about by means of eight long tentacles that express a giant's strength. With a spurt of water from its siphon the octopus may dart rapidly through the tank, and by directing the tube of its siphon, go whither it wills. Lying upon the bottom of an open trough, often buried in the sand, is the very interesting electric ray. If one presses the fingers upon the broad body where it runs into the tail he will, in the words of a Cook's guide, "get a strike." The electric tissues are descended from muscle fibers which in the course of evolution have come to produce electricity instead of motion. In the embryo ray the primitive muscle cells first appear, then they swell out anteriorly and shrivel up posteriorly until each loses the characteristic striated muscle structure and becomes an electric plate lying in a little compartment embedded in a jelly-like substance. Electricity is produced by some chemical action upon innumerable minute granules stored up in the protoplasmic network pervading the electric plates. The shock

is brought about by the stimulation of the electric nerve, which in turn acts upon very minute electric rods that release the electricity.

Above the aquarium is the library. In the north room are found in complete series all the most important biological journals. In the south room are the separate volumes, monographs and authors' reprints. The current numbers of journals and the latest publications from all parts of the world are found upon central tables. The classification and arrangement of the books is simple and the card-catalogue complete. Each worker is given cards bearing his special number in the general list and he inserts one of these cards in the place of the book desired. Dr. Schoebel, the librarian, is always ready with assistance in case of need. On the walls are notable frescoes by Hans v. Marées, one of the group of four especial friends of Dohrn when, in 1871, he was Privatdozent at the University of Jena. In the fresco on the east wall, Dohrn and these four friends, the biologist Kleinenberg, Charles Grant, the author of "Tales of Naples and the Camorra," the artist himself and the sculptor Hildebrand, are represented as grouped about a table at the ruins of the Palazzo di Donn' Anna on the Posilipo. In two other scenes, first Neapolitan fishermen are carrying the net from the shore and launching their boat and then four stalwart fishermen are rowing, standing in their characteristic manner and bending forward with each push upon the oar. On the south wall three ages of man are repre-



ECHINODERMS AND ANEMONES.



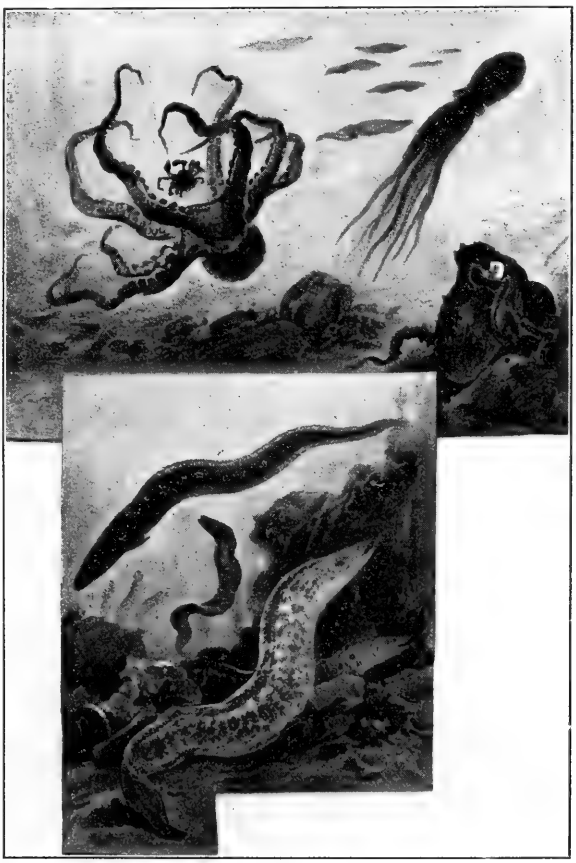
SEA-CRAWFISH AND OTHER CRUSTACEANS, MEDUSÆ AND CORALLINE ANIMALS.

sented in an orange grove; the child lying on the sand and playing, the man in his prime gathering the ripe fruit and the old man bending over his spade. The ornamental panels between the frescoes and the frieze, as well as impressive busts of Darwin and Von Baer, are by Hildebrand.

Three very important publications are issued by the zoological station under the able editorship of Professors Dr. P. Mayer and Dr. Giesbrecht. The *Fauna und Flora des Golfes von Neapel* consists of a series of more than thirty splendid monographs upon the animals and plants of the bay. Following the ideal sketched by Dohrn in 1880 as a foreword to the first volume, each monograph embodies the anatomy, histology, embryology and physiology, as well as the taxonomy, of the animals or plants of the group treated. Beginning with Chun's great work on the ctenophores, these monographs are models of a systematic zoology and botany based upon the whole range of biological science. They are beautifully illustrated by the authors themselves, often assisted by the talented artists of the station, Merculiano, Serino and Manzoni. The *Mittheilungen aus der Zoologischen Station zu Neapel,* now in its nineteenth volume, is a journal for the publication of shorter papers and contains the earlier annual reports of the director. The annual *Jahresberichte* contain admirable analyses of all the zoological literature of the year. While these publications contain many most important contributions, yet far beyond the limits of the station, almost every biological journal receives papers based upon investigations carried on, in whole or in part, in Naples, or upon material furnished by the institution.

For the purpose of meeting current expenses, in addition to the receipts from visitors to the aquarium, Dohrn conceived and developed the "table" plan by means of which various governments, universities

or associations may rent tables at which naturalists may work. By this means the station assumed an international character and remained free from governmental control, to develop under the wise direction and tireless energy of its founder, unimpeded by bureaucratic interference or the cumbersome machinery of a commission. At the cost of $500 a year a table may be taken and allotted to investigators in succession for the longer or shorter periods desired. All the resources of the institution are thus available to such an occupant without cost to himself. At present fifty tables are under contract. Germany has twenty-two tables, of which eleven are provided for by an imperial grant of twenty thousand Marks, while, in addition, Prussia has four and Bavaria, Saxony, Württemburg, Baden, Hessen, Hamburg and the University of Strassburg, one each. Italy has twelve tables, Russia four, Austria two, Hungary, Holland, Belgium, Switzerland and the Roumanian Academy, each one. In England the universities of Oxford



SQUIDS AND OCTOPI,
ROMAN AND CONGER EELS.

VIEW OF LIBRARY, LOOKING EAST.

and Cambridge and the British Association for the Advancement of Science have each a table. In the United States, the Smithsonian Institution has one, the Carnegie Institution two, Columbia University and the Association for Maintaining the American Woman's Table at the Zoological Station in Naples, one each.

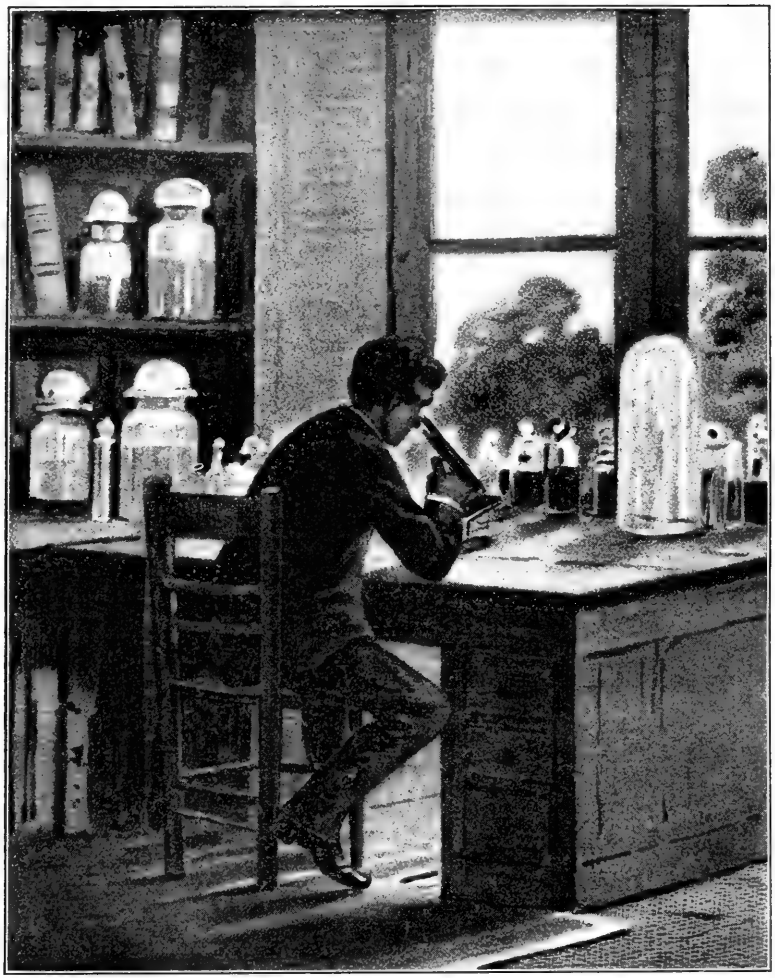
For the erection of the new laboratory of comparative physiology citizens of Germany have given 300,000 Marks, and with also at present an annual payment of 20,000 Marks, this country has shown implicit faith in Dohrn and his work. Of the 2,000 workers up to 1910, more than one half have been Germans. Besides supporting her tables, Italy has contributed 100,000 francs to the second building, and for over thirty years has given 5,000 francs annually to the library. During the thirty-six years since the founding of the station biological research has been awakened in Italy, until now her workers stand in the foremost ranks. In the early stages of the station English naturalists, headed by Darwin, gave £1,000 and thus assured Dohrn of international sympathy and support in his splendid work.

Dohrn, as owner and chief of the station, established the most complete system for the transaction of its business so that he always maintained the utmost confidence of the contributing governments and institutions. By the death of the founder, the directorship of the zoological station has descended to Dr. Reinhard Dohrn. That this great trust will be faithfully executed in the spirit of the founder's high ideals and will continue its remarkable development is evident to any one who knows Dr. Reinhard Dohrn. Each department is under

the direction of a member of the scientific staff, who is at the same time devoting his life to research in his own special field of natural history. At present the staff is organized as follows: Professor Dr. Mayer and Dr. Gross, morphology; Dr. Burian, comparative physiology; Dr. Henze, chemistry; Dr. Gast, the museum. One of the founder's first associates, Professor Dr. Eisig, now enjoying the benefit of the station's pension system, is still pursuing his life-work upon the annelids. The veteran secretary, Hermann Linden, assists in looking after the voluminous correspondence, and the local business with the city authorities, the railway, post and customs. A trained engineer and assisting machinists care for the electric motors, steam-engines, pumps and complicated network of gas, salt- and fresh-water pipes. In an especially equipped workshop a trained mechanic makes the instruments for experimental investigations. Dr. Lo Bianco developed beyond rivalry the department for the supply of animals and plants, either living for exhibition in the aquarium, or for the many workers in the various laboratories, or as perfectly preserved specimens for museums and investigators all over the world. Since the recent death of Dr. Lo Bianco his former assistant Sig. Santorelli has taken charge of this department. For collecting there is a fleet of well-manned boats, including the steamers *Johannes Müller* and *Francis Balfour* supplied with steam winding-reel for the dredges and trawls, and all sorts of nets and other necessary apparatus.

In 1885 Dohrn elaborated a plan of a floating laboratory for the extension of the work in marine biology. For this purpose a war-ship is too expensive to maintain and too ill adapted to the needs of investigation besides generally involving political and other interests distracting to biological research. An ordinary steamship would not be much better, so Dohrn planned a specially constructed and well-equipped

VIEW OF THE LIBRARY, LOOKING WEST.



THE LABORATORY OF AN INVESTIGATOR.

steamer of 300–400 tons of burden with an engine of from 150–200 horse-power and room for from six to ten investigators. Two laboratories, one above and the other below deck, completely outfitted for a six months' voyage together with a library would furnish ideal conditions for work. With such a floating biological station unknown regions could be entered with all the resources of modern equipment for both morphological and physiological work and investigations thus carried on which would not be possible upon land. To accomplish these results most economically the floating laboratory would be used, at first at least, in conjunction with the Naples Station, for the exploration of the bay of Naples, and the neighboring waters of the bays of Salerno and Gaeta. During the day-time the great depths would

be searched with dredge and trawl and fished with long lines, each bearing many baited hooks, and the pelagic animals caught from the side of the vessel. Small boats would be sent out to gather from the rocks and grottoes under the water-line such organisms as the sponges, corals, worms, echinoderms, mollusks and algae. A portion of the catch would be examined by the naturalists on board, another part kept in well aerated aquaria to be taken in the early morning by the *Johannes Müller* to the Naples Station. In the night-time silk townets would collect from the vast numbers of minute living things that then reappear after having gone below the surface waters to escape the intense sunlight. Stone-plates could be lowered to the sea-bottom in various places to be taken up and examined at regular intervals in order to study the assembling and growth of the sessile organisms that seek such locations. Then these stone-plates might be changed from one place to another, varying the depth, light and other conditions of existence in accord with the method of experimental zoology, with results of the greatest value to the knowledge of the distribution and evolution of marine organisms and scarcely possible except by means of such a floating laboratory. After exploring the sea around Naples the floating laboratory might be taken to the coasts of Sardinia, Tunis, Crete, Cyprus and other regions. The moment anchor is cast the vessel serves as dwelling house and laboratory from which would center all the activities of a marine station. If needed, a portable house, carried on board, could be quickly placed upon any desired shore. In connection with biology other kinds of scientific work such as geology, paleontology and philology might be advanced, with the best possible conservation of all the collections on board the ship, whereas it is often so difficult and dangerous to transport such things from isolated regions by the ordinarily available means. It is easily seen that such a combination would greatly advance the various sciences concerned at the least cost to each. This plan, always in Dohrn's mind, was temporarily laid in the background by the more pressing need of the erection of the building for comparative physiology which absorbed much time in the last years of Dohrn's life. Through the death of F. A. Krupp his promise to build a 700–ton yacht for this deep sea investigation came to naught. Now, although the Prince of Monaco is devoting much time and money to the development of oceanography, and various governments are sending out vessels, yet the field is so large and so important that it is to be hoped Dohrn's plan will be carried out not alone at Naples, but in America and other countries.

In spite of the time consumed in directing the affairs of the zoological station and in traveling and making addresses in its behalf, Dohrn was always an investigator of the foremost rank. During the half-century of continuous production his bibliography numbers eighty titles. Following in the footsteps of his father, the entomologist Karl

August Dohrn, his first two papers, published in his eighteenth year, were upon Hemiptera. Until 1881 his work was mostly concerned with the insects and other arthropods including his monograph on the Pantopoda for the *Fauna and Flora of the Bay of Naples*. However, as early as 1876, appeared the first of Dohrn's brilliant and suggestive papers on the origin of the vertebrates. Working upon the basis of embryological studies in such forms as the Ascidians, Amphioxus, the

THE ZOOLOGICAL STATION FROM THE EAST.

Cyclostomes, sharks, bony-fishes, and other vertebrates, Dohrn traced the phylogeny of the vertebrates to the annelid worms. Beyond their theoretical bearing upon a question still debatable, his discoveries constitute substantial additions to comparative anatomy and embryology.

The investigators at the station find intellectual and esthetic enjoyment in historic Naples and its neighborhood. Among the marbles and bronzes of the National Museum one finds such masterpieces as the Hera Farnese and the Narcissus. In Pompeii the uncovered auditorium and the uncurtained stage of the great theater seem to voice the awful tragedy of 79 in spite of the roses and larkspurs blooming

again in the peristyle of the house of the Vettii. In the present excavations one sees the volcanic debris removed from an atrium wall revealing in its pristine freshness a fresco of the brief period of reconstruction after the earthquake of 63. After the excursions from Naples certain pictures will always linger in the mind. The wonderful panorama from the Camaldulensian monastery extending from the Ponza Islands in the west to Monte Sant' Angelo in the southeast, and embracing the City of Naples with omnipresent Vesuvius in the background, and the islands of Nisida, Procida, Ischia and Capri. The view from the rose-garden of the Palazzo Rufolo, at Ravello, on the heights of Monti Lattari, with the fishing-boats of the bay of Salerno like winged creatures suspended just above the waves and gliding back to the gods who sent them forth. The temple of Neptune at Paestum, having withstood the devastation of wind and storm for twenty-five centuries, rising from the green meadows, with its massive yet graceful fluted Doric columns, sepia tinted by age, outlined against the blue sky and bluer sea. The blue grotto of Capri entered by a hole in the cliff so small that our little skiff scraped the rock, lighted by the sunshine which permeates the water from the one opening, and transformed into a great hall of fairyland with an atmosphere of silvery greenish-blue so clear that the primeval rock of the vaulted cavern is reflected in the shimmering depths below. The naturalists from many countries, all representing different phases of biological work and thought, create a cosmopolitan atmosphere most profitable and inspiring to each investigator. During the year ending March, 1910, there were 163 workers at the zoological station. Thus there is a perpetually changing and yet permanent congress wherein the exchange of ideas is not by means of formal lectures but rather in the conversation of two or three workers in some nook about the buildings, or upon the deck of the *Johannes Müller*. For the thirty-six years of its existence the Naples Zoological Station has been one of the most potent factors in the development of modern biology, and now this institution world-wide in its influence, stands as the chief monument to the remarkable personality of Anton Dohrn.

A UNIQUE COLLECTION OF ARITHMETICS

By Dr. LOUIS C. KARPINSKI
UNIVERSITY OF MICHIGAN

RECENT visitors to the Metropolitan Museum of Art have been impressed by the wealth of the loan collections standing in names comparatively unknown to the general public. A two-million-dollar sale of works of art lately excited only passing comment—in spite of the fact that many priceless treasures were forever lost to America. The existence of this private gallery was made widely known only through the dispersal of its paintings—and the unfortunate story of its loss to New York City. There are many other storehouses of those things which we human beings prize in this great city. Fortunately not all of them need to be destroyed as collections before their significance and charm receive adequate recognition. So the Morgan library in its own somewhat permanent home is now numbered among the city's choicest possessions.

The existence in the metropolis of an absolutely unrivaled collection of fifteenth and sixteenth century arithmetics has been brought to the attention of the scientific world by the publication of David Eugene Smith's "Rara Arithmetica." While the work purports to be a mere descriptive catalogue of the arithmetical books of the period mentioned which are in the library of G. A. Plimpton, it is in fact a comparatively complete bibliography of the subject, since this library contains practically all the arithmetic books published in the first hundred and fifty years of printing. As the third, and by far the most complete, collection of arithmetical works of international fame the Plimpton books take a high place among modern private libraries.

George A. Plimpton's interest in arithmetics grew out of his business as a publisher of text-books. The historical development of the school curriculum is exhibited by his library. Included are geographies from the invention of printing up to modern times, spellers, writing books with wonderful specimens of writing from all the world, geometries, reading books and representatives of the other subjects of the ordinary school program. But the gems of the collection are doubtless the mathematical works, for in these Mr. Plimpton's interest has been stimulated by Professor David Eugene Smith, himself an enthusiastic bibliophile. The bookshops of all the world have yielded their treasures to these indefatigable searchers. Professor Smith's recent trip

around the world brought mathematical finds to the Plimpton and Smith collections in the shape of Arabic and Persian, Hindu and Chinese and Japanese manuscripts and rolls.

Mention should also be made of the medallions of mathematicians, on exhibition in Teachers College, extending back nearly to the time of Pythagoras. The Smith collection of portraits of the devotees of numbers is without parallel and the autograph letters and documents are priceless. Here is an original note-book from the hand of Newton, and the more prosaic receipt for his semi-annual annuity of fifty pounds granted by parliament. The diploma of the great physiologist E. H. Weber, signed by Carl Friedrich Gauss, probably the greatest mathematician of all time, will interest especially those who are familiar with the labors of these men.

The invention of printing gave a tremendous stimulus to all scientific work by making possible the wide diffusion of knowledge, as well as by facilitating the intercourse of scholars. A potent indication of the really scientific spirit of the learned men of that day is the fact that the newly discovered art was used to give the older classics a wider circulation. Thus it need not surprise us to find in this bibliography of the fifteenth and sixteenth centuries the names of the more ancient writers.

Archimedes (287–212 B.C.), whom we ordinarily recall as a geometer tracing figures in the sand and incidentally being killed while engaged in this harmless occupation, or as a master of applied mechanics defending Syracuse with his catapults and burning glasses, appears in the "Rara Arithmetica" as the author of a work on numeration. Archimedes explains how it is possible to obtain numbers sufficient to express the grains of sand in a sand-heap as large as the world and even as large as the universe, a problem which is also found in India.

The arithmetic of Boethius (c. 480–524) involving that of Nicomachus of Gerasa (fl. c. A.D. 100) was the most widely used text-book in the monastic schools of the middle ages. Doubtless never again will any text-book be kept in use for approximately a thousand years, and yet an examination of the content of this text reveals not science, but hair-splitting philosophical discussions and extreme poverty of ideas. Boethius might have been expected to be a more practical philosopher, for he wrote his "Consolations of Philosophy" while he was in prison.

The exchange of professors by the leading universities was more common in the early days of these institutions than it is even now. Thus the Englishman, John of Halifax, or Holywood, who was known in the middle ages by the Latin form of his name Sacrobosco, studied and probably lectured at Oxford before settling in Paris about 1250. Sacrobosco's "Algorism," while by no means the first European work on the Hindu art of reckoning, was one of the most widely used and

served largely to spread the knowledge of the numerals which we now employ. This "Algorism" was first published at Strassburg in 1488 and at least thirteen other editions followed before fifty years had elapsed. In the first edition it appeared with a computus, the title applied to works on the arithmetic of the church calendar. The Latin version of our rhyme "Thirty days hath September," etc., appears in this "Compotus Manualis" (in verse) and was written by Anianus, a Strassburg astronomer and poet. The name algorism was applied for some five hundred years to the arithmetic which explained the method of reckoning with the Hindu-Arabic numerals. The word is a corruption from the name of Mohammed ben Musa, al- Khowarazmi, whose Arabic work on this subject was translated into Latin in the early twelfth century. Early manuscripts of Sacrobosco's classic are found in the Columbia Library as well as in the Plimpton collection.

Many theologians and churchmen, among the earliest of these may be mentioned the Venerable Bede (c. A.D. 700), and Cassiodorus (c. A.D. 550), amused themselves by writing arithmetics, but this was inevitable in the period when learning was so largely confined to church institutions. Thomas Bradwardin (c. 1290–1349), who was professor of theology at Oxford and later archbishop of Canterbury, wrote extensively on mathematics. His name suffered, as did many others, at the hands of transcribers, being found as Bragwardine, Brandnardinus, Bredwardyn, Bradwardyn, de Bradwardina and de Bredwardina. Another of these professors of theology was Christian Ursinus (also known as Allassiderus, Allassisiderus, Wursteisen or Urstis) who published in 1579 at Basel an arithmetic entitled "Elementa Arithmeticæ."

The surnames, as noted above, were rather shabbily treated from the modern point of view, since the first names were regarded as the important ones. It was common, too, for scholars to Latinize their names, or more rarely to give the Greek equivalent. The reformer Melanchthon, who appears as a writer on the nature and value of mathematics, was baptized Schwarzerd. Schreiber (c. 1525) became as a writer of school texts Grammateus, but was also known as Scriptor. Melanchthon's friend, Camerarius, who was also a classical scholar, was born as Liebhard. Camerarius wrote a commentary on the arithmetic of Nicomachus. Conrad Dasypodius, whose family name was originally Rauchfuss or Hasenfuss, wrote two works which should have been included in this catalogue. Copies of these rare books, both published at Strassburg in 1567–1570 and 1593–1596, respectively, are found in the Astor Library. The older one is entitled "First and Simplest Mathematics," and is partly in Greek and partly in Latin, treating of geometry, logistic (a Greek name for practical arithmetic), astronomy and geography. The writer was professor of mathematics at Strassburg

towards the end of the sixteenth century and he designed the famous clock of the Strassburg cathedral.

The unusually large number of physicians (eleven) appearing in the "Rara Arithmetica" is at first sight rather surprising, until we recollect that the scientific training of the time was largely confined to medicine. Some of these men might be counted among the best mathematicians of their day, notably the Italian Hieronymus Cardan (1501–1576) who attained fame as an algebraist, and the German Johann Widmann (fl. c. 1490), who wrote one of the first arithmetics in the German language. An English goldsmith is the author of a practical arithmetic, of which there were many designed especially for merchants and tradespeople. Jurists and numerous professors of Greek and Hebrew mingle here with priests and bishops and even two cardinals, Petrus de Alliaco and Nicolaus Cusa. The reckoning masters so frequently mentioned as authors remind us that for many years arithmetic had no place in the schools, and that the reckoning masters taught the art of reckoning outside of school hours very much as music and dancing are taught to-day.

Especial interest attaches, of course, to the first arithmetic to appear in print, the anonymous Treviso arithmetic of 1478. While there is no proper title page, the first page begins as follows: "Here commences a practical treatise, very good and very useful for any one who wishes to learn the art of merchants, vulgarly called the art of the abacus." The last page states that it was printed at Treviso (just north of Venice) on the tenth day of December, 1478. There are 124 unnumbered pages, running about 32 lines each. The first page is reproduced in the "Rara Arithmetica" in facsimile, together with three other pages. The author was evidently a teacher in Treviso, as he states that the book is written at the oft-repeated solicitation of his students; the printer's name is also unknown. Peculiarly enough this practical arithmetician applies four different names to the science, two as in the above title and further the art of "*arismetrica*" and *algorism*. This particular copy was in the Pinelli collection, and was acquired in 1790 by a Mr. Wodhull. Later it found its way into the library of Brayton Ives and at the sale of that library became the property of Mr. Plimpton. The work is strictly speaking an "algorism" since that title implied the use of the Hindu-Arabic numerals for practical computation, whereas "arithmetica" designated a theoretical treatise based largely on the work of Nicomachus and Boethius. An "abacus," strictly speaking, would be a work involving the use of some ruled surface or device to separate by columns (or rows) the units, tens, hundreds and thousands, etc., from each other. However these terms were not strictly applied, Leonard of Pisa's extended explanation of the Hindu reckoning appearing under the title "Liber Abbaci" or

"Book of the Abacus," while "Algorithmus Linealis" was applied to numerous works explaining the reckoning on lines which was a slight variation of the abacus idea.

The beautifully printed Calandri arithmetic of 1491, the first in De Morgan's list, differs from its predecessors in having the traditional problems copiously illustrated. The slow-moving snail, who climbs up by day one seventh of a foot and slides back by night one ninth of a foot, is seen here with his head just emerging from the fifty-foot well and looking remarkably active after a climb of 1,575 days. The title page presents Pythagoras as "Pictagoras arithmetice introductor," the wholly erroneous but wide-spread notion being that this philosopher was the originator of the science of numbers.

Of the eight or ten arithmetics (two being parts of compendiums) given by this catalogue as preceding Philippi Calandri's treatise the three following are of general interest. "Prosdocimi de beldamandes algorismi tractatus" (Padua, 1483) contains probably the first reference to a slate; Pietro Borghi, one of these successful text-book writers, wrote the most elaborate of the early books on the subject and more than any other set a standard for the arithmetics of the succeeding century. This text-book for the use of merchants, written in Italian, appeared at Venice in 1484 from the press of Ratdolt. Widman's German text of 1489 employs for the first time the + and — signs, but simply as warehouse symbols of excess or deficiency.

One of the rarest of the catalogued treasures is the "Arithmetica" or "Compendium of the Abacus" (Turin, 1492) of Francesco Pellos (Pellizzati). It appears that this native of Nice came very near to the invention of decimal fractions, writing almost a hundred years before the first complete explanation of the subject in "La Disme" or "The Decimal" by Simon Stevin the Hollander. Pellos actually used a decimal point to indicate division by such numbers as 100, but its full significance did not dawn on him.

The first printed discussion of arithmetic in the English language is a chapter of Caxton's "The Mirrour of the World or Thymage of the same" (London, 1480); the section begins "And after that of Arsmetrike and whereof it proceedeth." An interesting sidelight is thrown on early American history by the announcement of the discovery in Madrid of the first arithmetic printed in the western hemisphere. Extensive printing was done in Mexico in the second half of the sixteenth century, and it was here that Juan Diaz Freyle published in 1556 the Spanish "Compendium . . . with Certain Rules of Arithmetic."

Of necessity many works apparently unrelated to arithmetic are introduced. The fine distinctions between the sciences did not then exist, so that an astronomer, a geometer, a philosopher or a writer on the Church calendar would not hesitate to bring into his subject a dis-

cussion of arithmetic. Finger reckoning and a number game called Rithmomachia are other related subjects which received elaborate treatment. The first modern encyclopedia to appear in print is the "Epitome of all Philosophy" by the Carthusian monk Gregorius Reisch, the publication appearing in Strassburg in 1503. "Pythagoras" and "Boethius" adorn the first page of the part devoted to arithmetic.

It would appear that scientists have, in the course of centuries, grown more modest in their published claims. Borghi's "Noble work of arithmetic treating all those things which are requisite for merchants" sounds like a boast. More seductive are "The Ground of Artes," "The Castle of Knowledge," "The Pathway of Knowledge" and "The Whetstone of Witte," mathematical works by Robert Recorde, the royal physician to Edward VI. and Queen Mary. Recorde was the first to use the present equality sign, stating that no two things can be more equal than two such lines. His were the most influential English mathematical publications of the sixteenth century. Equally enticing as the titles of Recorde was Humphrey Baker's "The Well spring of Sciences, Which teacheth the perfect work and practise of Arithmetick, both in whole Numbers and Fractions" (London, 1562).

The most fitting name with which to terminate a discussion of the printed arithmetics of the sixteenth century is that of Adam Riese. So widely were his books used and so deep the impression which they made that even to-day, nearly four centuries after he wrote, the expression to reckon "nach Adam Riese" is common in Germany. Riese's works quite supplanted the numerous editions of the Rechenbuch by the versatile Jakob Köbel, who was Reichenmeister, printer, engraver, woodcarver, public official, as well as a successful text-book writer. Köbel's "Rechenbuch" of 1514 bears silent but eloquent testimony to the tremendous inertia that must be overcome by any new system that revolutionizes the common processes of thought. Köbel's arithmetic, four hundred years after the Hindu-Arabic numerals had been explained in Europe, is wholly in Roman numerals, even to the fractions. Riese's work made the publication of any other arithmetic in Roman numerals impossible.

Part II. of the "Rara Arithmetica" treats of the rich collection of mathematical manuscripts in the Plimpton library. The oldest of these is a beautifully written Latin Euclid (about A.D. 1260). This manuscript appears to be the copy given by the translator Campanus to Jacques Pantaleon when he was Patriarch of Jerusalem. Campanus was chaplain to Pantaleon both in Jerusalem and later when that churchman became Pope Urban IV.

An arithmetic written about 1339 by Paolo Dagomari, also known as Paul of the Abacus, furnishes the clue to the derivation of our per cent. symbol. The sign is derived from the abbreviation c° for cento

(hundred), and its evolution is traced through later manuscripts. As interesting, but not as conclusive, is an illustration from a fifteenth-century manuscript containing the possible progenitor of the dollar sign.

A beautifully written and illuminated copy of the Boethius arithmetic, written on vellum about 1294, is one of the most valuable pieces; the pigskin binding is of about the same date as the text. Just as valuable, because of the rarity of the material, is the copy of al-Khowarazmi's Algebra, a Latin manuscript of 1456. The title is "Book of Mohammed on Algebra and Almuchabala, or Restoration and Opposition." The word "algebra," like the words alchemy and almanac, is of Arabic origin, having the meaning "to restore." So a surgeon, restorer of broken bones, is called in Don Quixote an "algebrista." The word "almuchabala" contains the idea of balance. Both of these terms were applied to early algebras appearing in Europe.

That no expense has been spared in the preparation of the "Rara Arithmetica" is shown by the 255 photographic reproductions, largely full-page, which constitute one of the most valuable features for bibliophiles and librarians. The tremendous labor involved in searching out twelve hundred printed works, as opposed to De Morgan's one hundred, can be understood only by one who has tried to make a complete bibliography of any subject. The citations and references which have been given are sufficient to indicate the fundamental importance of the "Rara Arithmetica" in the history of the development of arithmetic. The actual additions in the notes, to our present knowledge, are entirely too numerous to mention. They show that the library offers a rich field for research in the history of mathematics. Bibliographically the "Rara Arithmetica" will always be an authority in so far as arithmetical books of the period treated are concerned and Americans may justly be proud that this work, which in the nature of the subject might have been considered more properly the field of a European scholar, has been so ably and finally done by a Columbia professor.

The first of the great collections of mathematical works at all to be compared with Mr. Plimpton's was made by Guillaume Libri, the author of the "History of the Mathematical Sciences in Italy." The first volume of his great work was just off the press at the time of the great fire in Paris in 1835. Libri, who had been at the printer's, took a few copies home under his arm; the rest were destroyed. One of the copies preserved, to which Libri made corrections for the second edition of 1838, is on exhibition in the museum of Teachers College, having been bought in Italy by Professor Smith.

Libri began his mathematical career as a boy prodigy, for at the early age of fifteen he was in correspondence with famous mathematicians, and at the age of twenty he was appointed professor of mathematics in the University of Pisa. Being exiled from Italy for political

reasons when he was twenty-eight years old, he took up his residence in Paris and later became a French citizen. His remarkable ability won him in the brief space of three years the chair of mathematics in the College of France and admission to the Academy of Sciences as successor to the great French geometer, Legendre. His activity extended to the political field as inspector-general of public instructon and later as inspector-general of the libraries of France. Soon difficulties of another nature overtook him, as he was accused of appropriating books and manuscripts from French libraries to his own use, in spite of the fact that he had previously offered his valuable collection as a whole, consisting of some 30,000 books and 2,000 manuscripts to the Royal Library of Paris on the rejected condition that it be kept intact as the Libri Collection. His conviction of the misuse of the national libraries occurred, many say unjustly, in 1805 and he was again an exile, living in England as a fugitive from the law; we will not say justice. His library was sold at auction in England, many of the works finding their way into the hands of Prince Boncompagni and after the dispersal of his library into the Plimpton collection and the private library of David Eugene Smith.

Prince Baldassarre Boncompagni, who gathered together a second famous collection of mathematical books and manuscripts, came naturally by his interest in scientific work, as he belonged to that same princely family as Pope Gregory XIII., who revised the calendar. While eminent as a contributor to mathematical literature, Boncompagni's greater service was as a patron of the science. At his own expense he published the "Bulletin of the Bibliography and History of the Mathematical and Physical Sciences," running through twenty volumes, with many valuable contributions by German, French and Italian scholars to the history of mathematics and astronomy. Even more important were his numerous publications in regard to Leonard of Pisa, who flourished at the beginning of the thirteenth century and to whom was due in a large measure the spread of the Arabic numerals in Italy and Europe. The publications of Boncompagni included two large volumes of the writings of Leonard of Pisa and two Latin versions of the Arabic work of Mohammed ben Musa, al-Khowarazmi, who made the Hindu art of reckoning known to the Arabs in the early ninth century; these Latin versions were made by a Spaniard and an Englishman, both of whom studied at that Moslem center of learning, Toledo, in the early twelfth century. Prince Boncompagni's magnificent collection was offered, on certain mild conditions, to the city of Rome, but was refused. While in printed works of the fifteenth and sixteenth centuries this library was not as complete as is the Plimpton, yet the equal of this collection of old mathematical manuscripts will doubtless never again be held by any private library. The sale at auction of these books took place as recently as 1898.

The small collection of Augustus De Morgan is worthy of note, as it furnished the stimulus for the publication of the first work dealing wholly with the bibliograhy of arithmetic, De Morgan's "Arithmetical Books," published in London in 1847. Of the fifteenth and sixteenth centuries De Morgan described some seventy arithmetics, while the "Rara Arithmetica" describes well over four hundred. A quotation from the prefatory letter by the great English mathematician in which the book is inscribed to the Rev. George Peacock, a writer on the history of arithmetic, is worth giving: "The most worthless book of a bygone day is a record worthy of preservation. Like a telescopic star, its obscurity may render it unavailable for most purposes; but it serves, in hands which know how to use it, to determine the place of more important bodies." De Morgan's felicity of expression in his numerous publications—he was an extensive contributor to encyclopedias—suggests his kinship to the present popular novelist, William Frend De Morgan, his son.

While the "Arithmetical Books" by De Morgan dealt wholly with arithmetical works, many others have treated the bibliography of mathematics. One of the earliest to give fairly extensive bibliographical references to mathematical literature is the "Kitab al-Fihrist," or "Book of Records," an Arabic treatise written in A.D. 987. The mathematical section of this large book was translated into German by H. Suter and appeared in Leipzig in 1892. The author, who went by the melodious name of Abou'l-Faradsch Mohammed ibn Ishak, or more commonly by the name Ibn Abi Ja'kub al-Nadim, included all the writers known to him, of whatever nationality. The Kitab al-Fihrist is of the greatest importance in the history of mathematics, as it is, indeed, in the history of the development of christianity, for the writer describes various early sects of the christians. An appreciably large part of our knowledge of Greek mathematics comes from such Arabic sources, for the Arabs kept the spark of Greek learning alive while Europe was in the darkest of the dark ages.

Our interest, however, is in the bibliographers who treated the early printed works. Gerard Joannis Vossius in 1650 published in Amsterdam his work, "On the Four Arts," which is an unreliable mixture of bibliographical and historical material. Naturally many histories of mathematics treated also the bibliography of the subject. The first German work to attempt a somewhat complete list of early printed books in mathematics was the "Einleitung zur mathematischen Bücherkentnis," which J. E. Scheibel completed in 1769 and of which at least two editions appeared. Other German publications, purely bibliographical, are F. G. A. Murhard's "Literatur der mathematischen Wissenschaften" of 1797 and J. Rogg's "Handbuch der mathematischen Literatur," which catalogued and described books from the invention of

printing up to 1830. The more general treatises on bibliography like those by Graesse and Hain and Copinger also touch this field, although of necessity only incidentally.

Aside from these there have been some purely national works like the "Bibliography of the Lowlands" of the mathematical and physical sciences by Bierens de Haan and the "Biblioteca Mathematica Italiana," by Pietro Riccardi. Professor Smith's "Rara Arithmetica" contains, for the period which it treats, more titles of Italian works than does Riccardi and more German than does Murhard or Rogg. In general, we may say, it is more complete for its specialty than any of the bibliographies hitherto published. The "Rara Arithmetica" may be said to be, with the exception of slight additions, the final bibliography of this field. It may safely be predicted that for centuries to come no other authority will appear to contest its claim to first place.

JOHN DEE AND HIS "FRUITFUL PREFACE"

By MARY ESTHER TRUEBLOOD
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IT may be necessary to introduce this "faithful student of the school of verity," for his contribution to human thought was of the kind that is easily absorbed in the sum total of the period, while the man himself remains little known to any but his contemporaries. The writer's introduction to him was through his "fruitful preface" to the first translation of Euclid's "Elements" into English printed in 1570.

That long preface is an interesting document in the development of intellectual freedom as well as in the history of science. It was addressed not so much to learned men as to the author's countrymen at large, though there was an occasional side glance at the university pedants. It expresses ideas strikingly like those for which the name of Francis Bacon stands, though written when Bacon was a boy of nine years. In it the author makes a vigorous appeal to the men of the time to shake themselves free from the commentational habit of the middle ages—to consider that the Greeks and Romans, who were held in such reverence, had not achieved all that was to be achieved. "Master Dee" was fully aware of the state of opinion that must be contended against. He says:

> Well, I am nothing affrayde of the disdayne of some such, as thinke Sciences and Artes to be but Seven. Perhaps those such may, with ignorance and shame enough, come short of them seven also: and yet nevertheless they can not prescribe a certaine number of Artes: and in each certain unpassable boundes, to God, Nature, and man's Industrie. New Artes dayly rise up: and there was no such order taken, that all Artes should in one age, or in one land, or of one man be made knowen to the world.

The immediate and ostensible purpose of the preface was to attract attention to the newly translated "Elements." The author begins:

> Neither do I think it mete for so strange matter (as now is ment to be published) and to so strange an audience, to be bluntly, at first put forth without a peculiar Preface.

In his pride in the achievements of England in the reign of Elizabeth, John Dee was at one with his countrymen, and whether consciously or unconsciously he appealed to men through the motive dominant in that period when he explained at great length how the "wonderful applications of mathematics" might be used for the glorification of the country. At the same time, the author sounds in advance a distinct seventeenth century note in suggesting that the laws governing natural phenomena might be better understood by being treated mathematically, and foreshadows the modern "Præcisions and Approximations-mathematik" when he speaks of "allowing somewhat

to the imperfection of Nature not answerable to the preciseness of demonstration."

The preface is framed for such

who well can, (and also will) use their outward senses to the glory of God, the benefite of their Country, and their own secret contentation, or honest preferment on this earthly Scaffold. To them I will orderly recite, describe and declare a great number of Artes, from our two Mathematicall fountaines, derived into the fields of Nature. Whereby such Sedes, and Rotes, as lye depe hyd in the ground of Nature, are refreshed, quickened, and provoked to grow, shote up, floure, and give frute, infinite, and incredible. . . . At this time I define an Arte to be a Methodicall complete doctrine, having abundancy of sufficient, and peculiar matter to deale with, by the allowance of the Metaphysicall Philosopher: the knowledge whereof, to humaine state is necessarye. And that I account, an Art Mathematicall derivative, which by Mathematicall demonstrative Method, in Numbers, or Magnitudes, ordereth and confirmeth his doctrine, as much and as perfectly, as the matter subject will admit.

It seems certain that John Dee had also a conscious belief in the value to science itself of the application of its principles. He invites his reader to "consider the infinite desire of knowledge, and incredible power of man's Search and Capacitye how, they jointly have waded farder by mixtying of speculation and practise." Compare with this a sentence by Ernst Haeckel written three centuries later:

We must welcome as one of the most fortunate steps in the direction of a solution of the great cosmic problems the fact that of recent years there is a growing tendency to recognize the two paths which alone lead thereto—experience and thought, or speculation to be of equal value, and mutually complementary.[1]

John Dee's long life covers a dramatic period in the history of the development of thought, and as the most widely known English scholar of his generation his education and wanderings are interesting. It was in 1526 that the books were burned in Oxford in the futile attempt to stop the new learning. In the following year John Dee was born of the ancient family of Dees of Radnorshire. His father, Rowland Dee, was by some accounts a vintner in London, by others he is described as gentleman sewer to Henry VIII. Whatever his occupation, he was a friend to the universities, and in 1542 sent his son to St. John's College, Cambridge. Here he remained, first as student, then as foundation fellow, until 1546. When in the same year Trinity College was founded by patent of Henry VIII., Dee was made one of the original fellows and was, as he says, assigned there to be the "under reader of the Greek tongue." At the same time he was occupied with mathematical and astronomical studies and on "going down" gave to Trinity his astronomical instruments.

At that time the men of the universities seemed not to aspire to know more than was to be learned from Plato and Aristotle. That John Dee had a mental appetite beyond the ability of Cambridge to satisfy appears from his account of his wanderings.

[1] "Riddle of the Universe," p. 18.

After I was Batchelor of Arts, I went beyond the seas (Anno 1547—May) to speak and confer with some learned men and chiefly Mathematicians. . . . Anno 1548 I was made Master of Artes. I became a student at Lovain 1548 midsummer, and there I made abode, till the 15th of July 1550. . . . From Lovaine I took my journey towards Paris Anno 1550, . . . where within a few days (at the request of some English Gentlemen, made with me to do somewhat there for the honour of my Country) I did undertake to read freely and publicly Euclid's Elements Geometrical . . . a thing never done publicly in any University of Christendome. My auditory in Rhemes College was so great . . . that the Mathematical Schooles could not hold them; for many were fain, without the schooles at the windows, to be auditors and spectators as they best could help themselves thereto. I did also dictate upon every proposition, besides the first exposition.[2]

John Dee was held in high esteem not only in Paris and Louvain, but at almost all the courts of Europe. He relates (and there is no reason to question the statement) that he might have served five Christian emperors, namely, "Charles V, Ferdinand, Maximilian, this Rudolph and this present Moscovite," but Queen Elizabeth "very graciously" took him into her service. Just what the service was that is referred to here is not evident, but the Queen called upon "Master Dee" for a great variety of services. At one time he instructed her in astrology, using the book which he had written for the Emperor Maximilian. Once he was sent for post-haste to prevent mischief to her majesty's person apprehended from a waxen image of her, found in Lincoln's Inn Fields with a pin stuck in its breast. In 1577 the queen sent for Dee to come to Windsor on account of a comet, and for three days she listened to his discourse and speculations on the subject. Five years earlier there had appeared a brilliant star in "Cassiopeiæ" that caused such consternation among the people that John Dee and Thomas Digges united in an attempt to give an explanation and bring to an end the terror of the people. As a result Dee printed in 1573 his "Parallacticæ commentationis praxeosque nucleum," but not content with that, he printed in the same year a work entitled "de Stella admiranda in Cassiopeiæ asterismo cœlitus demissa ab orbem usque Veneris." Knowing the superstitions of the times, Dee frequently urges the desirability of man's understanding nature. After enumerating various natural phenomena, he asks:

Is it not commodious for man to know the very true cause, and occasion naturall? Yea, rather, is it not greatly against the Souverainty of man's nature, to be so overshot and abused, with thinges (at hand) before his eyes?

In 1580 the queen desired to know her title to countries discovered in different parts of the world and Dee drew up for her two large rolls of description and maps which were approved by the queen and Lord Burleigh. Not only the queen, but explorers, men of affairs and the learned men of Europe sought him out. To him came Sir Humphry Gilbert and John Davis to talk of the Northwest Passage (John Dee

[2] Dee's "Compendious Rehearsal."

himself wrote two works on navigation). The East India Company called upon him to improve the compass. Certain large landholders in England who had mines extending under their boundary lines came to him to settle their controversy. In 1582 Dee was urging the Queen to improve the calendar, and two years later she and her ministers requested him to make the necessary calculations. The Roman Church amended the calendar on the supposition that all that was done at the council of Nice with regard to chronology was correct and proposed the omission of ten days, but Dee's calculations led him to recommend the omission of eleven days. He agreed, however, to compromise for the sake of uniformity, providing the facts should be publicly announced. The plans were approved by the lay members of the committee, Thomas Digges, Henry Savile and Mr. Chambers, but opposed by the archbishop and bishops on the ground chiefly that the project of reforming the calendar emanated from the See of Rome. The reform was thus delayed one hundred and seventy years, but Dee's able treatise was preserved and was made use of when the change actually took place. The original has passed through the hands of many eminent mathematicians, and is now in the Ashmole collection at Oxford.

This treatise on the calendar, the "Fruitful Preface" and the memorial to Queen Mary in regard to a royal library are the most significant of his seventy-nine works, many of which were never printed. In the last-named Dee called the queen's attention to the fact that with the destruction of the cloisters there was no longer any place of safety for manuscripts, and that these were now being destroyed or scattered broadcast. He set forth the loss this would be to history and science, and proposed that a commission should be appointed to establish a royal library—he himself undertaking to procure copies of famous manuscripts at the Vatican. Whether because of his youth or because of the indifference of the Queen, he was not listened to, but in his own library at Mortlake he collected 4,000 books, of which he tells us "700 were ancient manuscripts in Greek, Latin and Hebrew."

John Dee early accepted the Copernican theory and was apparently among the first to understand and give due weight to the writings of Roger Bacon, to whom he refers as a "philosopher of this land native (the floure of whose worthy fame, can never dye nor wither)." It was to him doubtless that Dee owed his high valuation of experiment in science. He begs of his readers to

> Esteeme one Drop of Truth (yea in Natural Philosophie) more worth, than whole Libraries of Opinions undemonstrated or not answering to Nature's Law, and your experience. . . . Words and arguments are no sensible certifying: nor the full and final frute of Sciences practisable.

That many of the opinions held by Dee were not common among even the learned of his countrymen is evident from the manner in which he exhorts them in his writings. He too held out a hand to "divine

Plato," sometimes with an apology, but from his influence Dee had escaped farther than he himself perhaps knew. The amount of space given in the "Fruitful Preface" to the explanation of the uses of mathematics and the record of his varied activities give abundant proof that this scholar believed in making knowledge effective for the benefit of mankind. It is impossible to go through his writings without suspecting that here is one source of Bacon's ideas. John Dee preceded Francis Bacon at Cambridge by thirty years, and were there no positive proof of their acquaintance it would not be probable that a man known all over Europe for his learning and frequently called into service by the Queen and her ministers should remain unknown to a young courtier with the omnivorous intellect of a Francis Bacon. For many years Dee kept an intermittent diary on the margin of his almanac in which is found this note:

Aug. 11—1582. Mr. Bacon and Mr. Phillips of the court called.

Sir Nicholas Bacon was prominent at the court of Queen Elizabeth and his two sons, Anthony and Francis, were court favorites, while yet in their teens. As Sir Nicholas died in 1579 and Anthony Bacon was on the continent in 1582, the "Mr. Bacon of the court" could not well have been other than the young Francis. According to Bacon's own testimony, he wrote his first letter on the "Instauration of Philosophy" about 1583.

Looking at this "faithful student of the school of verity," this "old forworne mathematician," as he styles himself, we see a scholar familiar with the contributions of all men up to his time, a pilgrim to every shrine of knowledge; we see a councillor of kings, an adviser of explorers and men of affairs, a proud patriot, a profound believer in the ability of man to obtain sovereignty over the forces of nature, a courageous man throwing down the gauntlet to authority. But there is a reverse side to the picture. The desire to force the secrets of nature, of which he had a deep presentiment, became a ruling passion. In the midst of a discussion of "Statike (experiment of the Balance)" he breaks off with this prayer:

Oh that men wist what profit, (all manner of ways) by this Arte might grow, to the hable examiner and diligent practiser. Tho only, knowest all things precisely (O God) . . . who hast created all things in Number, Waight, and Measure: and hath wayed the mountains and hils in a Balance: who hast peysed in thy hand both Heaven and Earth, . . . and being farther advertised by thy merciful goodness that, three principall wayes, were, of thee, used in Creation of all thy creatures, namely, Number, Waight and Measure, and for as much as of Number and Measure, the two Artes (ancient, famous, and to humaine uses most necessary) are, all ready, sufficiently known and extant: This third key, we beseche thee (through thy accustomed goodness) that it may come to the nedefull and sufficient knowledge of such thy servants, as in thy workmanship would gladly finde thy true occasions. . . . Amen.

Mervaile nothing at this pang (godly friend, you Gentle and Zealous Student). An other day perchance, you will perceive, what occasion moved me.

Could John Dee have lived another century he might have found in the work of Isaac Newton some answer to his prayer. The very intensity of the longing to understand the mysteries of the universe was in part the cause of the errors into which he fell. His belief in astrology and in the value of the alchemical experiments on which he spent so much of his energy and substance may be accounted an error of the time rather than of the individual, but his long connection with Edward Kelley—charlatan and magician—is not easily reconciled with his intelligence. Kelley, at first an apothecary, became an avowed dealer in magic and seems, for a time, to have made a complete dupe of Dee, who in all good faith admitted him as a valued assistant in his researches and travels. Between the years 1582 and 1589 they were making alchemical experiments, peering into crystals, communing with spirits, etc.—part of the time in England, part of the time on the continent—chiefly at Prague. When in 1590 the real character of his masterful assistant became apparent, Dee experienced the keenest sorrow over misplaced confidence.

But for the time of his wardenship of Manchester College, 1596–1604, he spent the remaining years of his life at Mortlake in poverty and sadness. Queen Elizabeth, in passing to and from Richmond, often stopped to question and console him and sent her own physicians when he was ill. From the records of the time "Master" Dee seems to have made a deep impression on the people round about, both because of his learning and of his handsome presence. Aubrey speaks of him as a great peacemaker among his neighbors, and adds "a mighty good man was he." By some Dee was accounted a conjuror, and so oppressed was he by the charge that he petitioned James I. in 1604 that he might be tried and cleared of the horrible slander. After the king had inquired into the nature of his studies the petition was refused as unnecessary. Up to his death in 1608 Dee retained the profoundest interest in experiments. His magic crystal and cakes are preserved in the British Museum.

Though his actual contribution to science was not great, John Dee belonged to and had an important part in the transition from the commentatorial period of the middle ages to that time of bold originality and vivid reality—the time of Bacon, Kepler, Galileo and of their young contemporary, Descartes. His eyes at least were above the plane on which Francis Bacon stood. Forerunners such as Dee prepared the way for the stupendous achievements of the seventeenth century—that century made notable by the introduction of the most powerful mathematical methods and by the use of these methods to obtain an understanding of the laws that govern the phenomena of nature.

THE MAKING OF THE SCIENTIFIC INVESTIGATOR

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THE question is old but important, how far a man may influence his destiny and career by power of will and by training. Very often it is argued that his future lies entirely with himself, that he is modeling clay in his own hands. From this comes the expression of "the self-made man." Yet "there's a divinity that shapes our ends, rough hew them how we will," a might that the biologist calls inheritance. For by no manner of endeavor can a man make himself a bird or fish, nor can he divorce his mind from his body. An organism may be introduced to new conditions of life, by volition or by circumstance, and though it may change to some extent, it can not become entirely different from what it was at the start and still continue to live. As the twig is bent the tree inclines, that is, bends off from the normal path, but it does not become another kind of tree. The gardener can change the growth of a flower by placing certain solutions in the soil, but he simply adds another substance to it; or the experimenter can prevent a skeleton from developing by withdrawing from the medium certain salts, but he has only subtracted a certain substance. Some qualities may receive an added impulse, others may be retarded, monsters may be engendered, but no man has yet changed one being into a very different one.

Thus there are genetically diverse kinds of beings, and this is as true for men as for the rest of creation. What will be the outcome of any individual is to greatest extent a matter of his inheritance, it is blood that tells. All of us make our advent naked and helpless, all seemingly equally dependent upon the maternal care, all have to learn by experience. Yet no two human infants are alike, except to the inexperienced eyes of an old bachelor, for because they are of different parentage they possess at the beginning different qualities, and it is probable that infants are as unlike as full-grown men and women, though in not the same ways. Indeed, every step in our growth has been conditioned by our ancestry. For the organism is much more than a set of substances and structures, it is a chain of processes linked continuously with the remote past and the outcome depends very largely upon the initial condition. This is the cardinal point that educators have grasped only recently, and about which some of them are still strangely in doubt. A man can not mold himself entirely, nor can his teachers wholly change him, for he is largely fashioned by his inheritance.

But though inheritance handles the reins, the course of life depends

much upon the finding of the right road. Only the *Universalgenie,* if such exist, could arrive at the goal by any of the divergent roads.

The true aim and project of the university seems to me to be, in the first instance, to help the man to find himself, and only in the second instance to educate him. For the reason that this may appear an unusual view it should be explained. Universities arose out of the desire for freedom of thought, out of the wish to break the fetters of formalism. At various times, at Salamanca and Bologna, Strassburg, Paris and Oxford, assembled groups of men who had become dissatisfied with the crystallized curriculum offered by the church schools, who felt the curb on thought. Consequently they segregated, and from their number selected those men as teachers who had new and fertile ideas. Thus within such an assemblage all subjects came gradually to be professed, and each man chose his disciplines according to his inclinations. That is to say, universities in their inception were places for freedom of choice of subject, and this has remained the ideal in at least the more influential continental universities. One expression of it is our elective system, but it is pursued still more broadly in Germany. There the student comes from the fairly rigid curriculum of the Realschule, or the still narrower course of the gymnasium, to the university where he may select just as many courses and just what ones he cares for. The result is a double one: he frequently chooses as few lectures as possible, and then enjoys several Bummeljahre; but drones are no honey getters, and, provided he need a profession, he sooner or later comes to hear lectures on a great variety of subjects until he finds the one that most engrosses his attention, when he devotes himself to that. This system, in the nearly complete freedom of choice it allows, offers the fruits of all sciences, so that by browsing in this diverse orchard the student may find his peculiar taste.

A graduate department is not an Eden simply because all are commanded to eat of the fruit of the tree of knowledge. Men come to it from undergraduate courses where they have followed rather delimited curricula; in it they are free to make choice of the profession of their lives. It is the duty of the graduate school, the university proper as seen in the historical setting, to help each man to find himself, which is but a paraphrase of the Socratic "know thyself."

Students come with different innate propensities; they should choose the fruit that comes nearest their hearts. The decisive step towards success is to choose wisely, which means simply to elect that which attracts most strongly. That is, one should place himself in the soil for which providence or his inheritance meant him, for only by so doing can one develop his capabilities to the full. And if there be one duty set upon us, a duty to our neighbors as well as to ourselves, it is to do that for which we are best fitted, granted only that a man be of sane social judgment.

The occupation of a lifetime is not to be chosen by cold reason, but by the warmth of the heart. When friends go and the purse gets lean, a man may be kept warm by the enthusiasm for his work. When we always recur to our work with delight we make the most of our futures. Much of the success of an investigator lies in his choosing rightly, and the test of one's fitness is the durability of one's zeal.

Many and varied temptations there are to lead one astray from such a choice, the most seductive of which is escape from financial care. All of us can appreciate this, and the more perhaps because the multitude is apt to measure social standing by material wealth. But we will not linger over this time-worn and hoary subject of dispute, beyond noting that such thinkers as Dante and Harvey, who added so marvelously to our understanding of man, were neither rich nor yet in society. What immediately concerns us is that the investigator requires all of his ability to achieve results, and he certainly will have less success if he sacrifice his stronger inclinations for any social or mercenary reason. Let our financial futures take care of themselves, let us guard our talents. There is room at the top; it is only the bottom rungs that seem insecure.

Most men when they have obtained their doctor's degrees feel suddenly helpless, thrown out upon a chilling world. As a result most feel they should secure at once some sort of a remunerative position, and they are apt to think the position better the more it pays. This seems to me to be on the whole a pitiable error, and the reason why is very simple. For if young men have decided upon scientific research they surely will require time for their researches. It is rarely the case that they can occupy any school position and still have opportunity for their own work. Therefore the positions that are best for them are ones that make the least demands upon their time, and most of these are found only in universities. Suppose then a man should be given the choice of an instructorship at $1,500, in a high school or small college in which he would have no time for investigation, and of a graduate fellowship of $500, in which he would have every minute for his work, he should choose the latter no matter what worldly sacrifices he must make. For by this choice he would be gaining time, he would have opportunity to make a name for himself, and if he did not lose heart but remained true to himself he would certainly arrive at the proper kind of a position. If a man become side-tracked into a school teacher's chair, for the poor reason that he gets a living salary quicker, he will never be heard of and never get out of it to realize his ideals. The dollar may seem big, but time is more productive capital than money.

Yet, at the same time, it should be noted that a certain amount of teaching is good for the investigator. For in the first place a body of students enables him to farm out parts of his problem, and by establishing in this way a special school he is able to accomplish much more

than he could single-handed. He can not by himself answer the whole of his problem, but with the help of a corps of students, each prosecuting some particular part, he may be able to; and the students themselves gain by cooperating in such a unified project. For no one man has the ability to follow out all the clues that suggest themselves to his mind. And in the second place, a certain amount of teaching is almost necessary to prevent a man from becoming narrow, and to keep him in active touch with all sides of his subject. It is particularly important for an investigator to teach undergraduate courses, though these are the most difficult to present well, for that keeps him in touch with the broader and more generally comprehensible parts of his work. The occasional meeting with younger and fresher minds is stimulating, and clear presentation of a subject to them often clarifies our own ideas. It is probably on account of their teaching that university men are generally broader than museum curators.

Given then the opportunity to measure the different paths of knowledge, and supposing a man has made his choice congenial and has resolved to stick to it, a great step has been taken. Yet this is, after all, merely the planting of the right seed in the proper ground, much remains before the harvest. To make the simile true we should imagine that the case is one where a man is at once seed, farmer and harvest, limited and constrained by his inherited powers. We have to find our particular effective seed, to set it out with care, and to keep its nurture mainly in our hands.

The subject matter of a science can be taught us, but we have to learn to investigate mainly through our own endeavors. The teacher out of his experience can indicate a problem awaiting solution; he should be able to decide whether it be soluble, but the real work, the research, is with us. One can learn investigation only by investigation, and each man must find his own path through the maze.

Encyclopedic knowledge is often more an impediment than a help to investigation; the two are contradictory. The student may become so charged with scholastic learning that he has no room left for thinking. And as we recall the creative thinkers of the past, we find they were on the whole rather undertrained men, in consequence untired and active in thought, picking up knowledge only when it was needed. For knowledge is not an end but only a tool. Yet there still lingers the idea that during the three or four years the student devotes to his doctorate, he should try to learn the whole of his subject! University teaching, it seems to me, should be called successful only when it helps a man to independent thinking. It is wholesome to recognize our limitations, to realize that we can not carry heavy freight and at the same time make headway. The mind that has to interpret must be fresh and agile, not loaded with the thousand and one opinions of forerunners. Let us avoid burdening our strength with laborious compila-

tion. We sometimes think we are getting wise when we are only getting rusty.

It is this consideration that indicates a man should receive very little help with his doctor's thesis, he should sink or swim without the help of a convenient raft—or professor. For then is the witching time when he is finding out whether he holds the power of research, and he alone can tell whether he has it; he can tell by a certain elation and undefined feeling of strength. The student should be given a soluble problem for his thesis, also certain technical aid, then left rather severely to his own devices. If he succeed he will have proved his ability; if he fail it is still well, for he will be saved from an ill-chosen career. While, on the other hand, the result of aid constantly given is what we may call the "one-thesis man," he who finishes his thesis, to be sure, and gets his degree, but who afterwards, when he is thrown upon himself, proves unable to carry out further investigation. The best test of a leader of a school of investigation is not the number of doctors graduated, but the number who afterwards actively continue to investigate. For their own good students should prosecute their problems so far as possible without extraneous help.

The highest that graduate work can foster is independent thinking, not scholastic learning. A man may be led to knowledge, but he can not be made to think.

There are three particular gifts that the investigator should cherish to his utmost, imagination, judgment and the maintenance of an ideal.

As the insect stretches out his antennæ, feeling and smelling at once, forming thereby an idea of what is ahead of him, so it is that by the help of our imagination we can reach out into the unknown. Blind searching for a clue is not profitable, and it is waste of time to expect some happy fortune to bring an answer to us. Science is not a game of chance. It is necessary to form tentative explanations, and the working hypothesis is the outcome of the imagination much more than of the reason. The reason deals with the known and experienced, it is the imagination that must as a pioneer leap into the unknown. Thus the scientist makes his soundings and feels the depths. He has to forecast various possibilities, and to test these severally. Yet the imagination is only a feeler and not a leg to stand upon. We must bear in mind that hypotheses are but suggestions, invaluable though they be in directing effort, and that the real labor of the scientist is the testing of his hypotheses. The immediate subject matter of all of us, physicist, mathematician, chemist, philologist, whatever our calling may be, is hypothesis, and out of hypotheses we have to reach explanations; an explanation so attained is a theory. We must not confuse hypothesis with theory, nor inflict upon suffering colleagues, much less publish, all our hypotheses. If, as Goethe says, all theory is gray, how colorless must hypothesis be until it has been turned to account.

For these reasons the man of science may be very directly benefited by a study of the great poets, and he will learn thereby how close is the bond between science and art. Yet many still hold the strange idea that the scientist lacks all fancy, as though he could ever explain without the help of it! He who has no gift of imagination has no place in science.

It is by what we call judgment that we measure our hypotheses. This comes in the main from experience, is capable of nurture, and is well characterized as good sense.

In his haste a man may try to run straight through a briar patch, but if he has common sense he will, like the renowned Br'er Rabbit, hunt out some trail; so he will reach the clearing quicker though he can not show so many honorable scars. Herein lies the main value of studying the lives of the masters of thought. Of each man who has markedly advanced knowledge we should make a hero, and humbly try to follow his footsteps by analyzing his methods of work. Indeed, this study of personalities should not be limited to the great, for from every man that we meet we may learn something to help our own working method; that is, we may learn if we try to. Each of us realizes that we can not give a correct estimate of a man's work unless we know his personality, Shakspere always excepted. Therefore to judge of scientific data we can be greatly aided by measuring personalities. It is then suggested, to help us to a sound judgment, to analyze the individualities of others, to see how they came by their results. This is the chief value of all collegial intercourse in seminar and society meetings. A fellow student is often the best of all teachers. And for the same reason it is well worth the time both to study the history of one's subject, that is, the methods and especially motives of its founders, and to read reverently and lovingly classical monographs whether they be now fashinable or not. How many of us do actually read Aristotle, Newton and Helmholtz? It is such study that enables us to see modern discoveries in their proper perspective, and restrains us from fancying each mole hill to be a mountain.

Breadth of judgment may be helped by catholicity of interest. Some men seem to do their best by devoting every energy to one problem, seeing nothing outside of it. Their mind is a short-focus lens with consequent penetration, but it can not see the garden for the weeds. It is perhaps more wholesome, however, and it certainly leads to a nicer mental balance, to respect all good endeavor and to try to understand at least the fundamentals of our sister subjects. This indicates the choice of a problem that is not circumscribed, but that leads into an ever-widening field. It further indicates that we should breed acquaintance with subjects quite apart from our own, to see the relations of our work to that of others. Expression of contempt for any

source of knowledge is an acknowledgment of ignorance, and meagerness of ability is to be measured by narrowness. That investigator with a foreshortened horizon will find everything small.

We hear it said that in science all facts have an equal value, just as all links in a chain have equal importance. If this were so, then all problems of science should have an equal significance and it would make no difference what choice of problems were made. But the premise is wrong, because we generally recognize that some phenomena have very wide bearings while others do not, or at least do not in our present understanding of them. Thus the phenomenon of the size of an animal has not nearly so much significance as the phenomena of its rate of growth or alternation of generations. We measure the value of a phenomenon by the number of ideas we associate with it, that is, its relative degree of complexity. As in art a painting of a basket of fruit, no matter how excellent the technique, can not be compared in value with a study of a human face, so in science the discovery and description of a new muscle, no matter how accurately made, can not be paralleled with an investigation of the process of formation of that muscle. The human face and the process of differentiation call up ever-widening associations, while the basket of fruit and the muscle suggest a meal. To be sure, a master artist might make the basket of fruit appear celestial, and a great anatomist make the muscle seem extraordinary, but they would still suggest a meal, even though a meal for angels or heroes. Men will differ as to the relative importance of any thing, and we have no right to prefer our estimates to others. But it is generally acknowledged in science that the investigation of a process is of a higher order than the contemplation of one particular step, the number of comparisons possible being the criterion of value. Thus it is certain that all problems are not of equal value, because they have very different bearings. All need solution, they are of sufficient diversity to appeal to all types of mind, but a man should assure himself that his problem has really broad significance. And when the layman approaches us on the manner of our work we should not tell him, as is often done, that he can not understand it because he is not a scientist; for if we can not make it intelligent to him it is clear we have no good comprehension of its bearings, and the fault is with us and not with him. Every scientific research has some connection with human interests we should understand what the connection is; if we do not understand this we are to blame for any lack of sympathy. It is a duty of the investigator towards his subject to make it comprehensible to the layman, and when he does so his merits will be acknowledged, but not before.

Like every other process, so thought needs time, and by reflection is meant thought pursued at leisure. When a certain result has been

won in our researches, and its bearings seem misty and uncertain, we gain nothing by filling the ink pot and knotting a cold towel around our heads in full determination to settle matters. Dogged does not always do it. Put the idea away in some corner of the mind to give it time to germinate, then bring it out at intervals for consideration. This mental chewing of the cud is wholesome because natural. When the way seems darkest and most beset with stumbling blocks we may be nearest the door, and it is best to go slowly in the dark. We attain our conclusions at unexpected moments and have generally to wait until they appear subconsciously, the time varying with the individual mind.

It is often an aid to reflection to drop for a while the subject that has begun to worry us, to take up a different and fresh problem. This alternation of subject is a necessary mental recreation and frequently accomplishes more than long hammering. For any change of thought is stimulating.

Yet the investigator need not be like Heine's "gray friend between two bundles of hay," slowly starving to death because he can not decide; it is better that he choose unwisely than not choose at all, else he can not maintain himself in the arena of thought. After all, if he eats one of the bales of hay and learns later that the other was larger and sweeter, he has not gone hungry.

It would seem to be on the average best for the general man to take rather a middle stand in his judgments, which means to see the good in both sides of any question. One should be neither too critical nor too tolerant. New ideas are constantly emerging, many of them contradictory to our own, and we have to cultivate a mode of meeting them, not to be bristling like the fretful porcupine, nor yet to embrace them eagerly because they are new. Also it is not safe to say an idea is wrong because it is new. We should react towards views as towards our fellow men, hunt for the best in them. Nothing is easier than to criticize, nothing less constructive. Life is too short for full achievement, unless Metchnikoff's prophecies may come true, and "Like as the waves move on the pebbling beach, so do our minutes hasten to their end." Then why misuse the moments in picking flaws? In the orchard before us we may readily find the insect-bitten fruit if we look for it, but what pays is to gather the good. Whether it be right or wrong from the philosophical aspect, the optimistic standpoint is the most wholesome, and that man is happy who sees only the good in others—in their personalities as well as in their opinions. We all shun him who has the squinting mind of noting only mistakes. Let us be fair to other men even though we can not be impartial, if only for the reason that it is the best policy, as Franklin would have said. For if we are not so, the retort courteous will be harder than the blow we struck, and then will be our time to wince.

We are least objective about ourselves and that is why we can never decide what is our own merit and achievement. For while the ambition to excel is both justifiable and desirable, the true mirror of success must be the eyes of others. Geniuses are really exceeding rare, yet every man is inclined at some period or other of his existence to think himself one, and a fool continues to think so. On the whole, we do not deserve more praise than we get, the world's estimate being reasonably fair; and in fact it is incorrect to talk of deserts since each man carves for himself his slice out of the cake of his own baking. Perhaps the happiest stand we can take is to lose consciousness of self, to think of results but not of our part in them, to come to comprehend that our subject and the sunlit world outside of us is much more engrossing than ourselves. From the philosophical side this attitude may be incorrect. But a new philosophy is gradually forging ahead, that men do not contain the whole universe in their minds, that phenomena are not wholly subjective, but that nature is one great unit of which we are only inconspicuous morsels. This is certainly the philosophy of biology. It places us in a truer perspective, and aids us to be more objective and therefore happier. Fortune is a fickle goddess who keeps beyond those who seek her, to touch those who made their work their grail. Thus what we accomplish, and how we have done it, is a matter to be decided by other men and usually by other men of a later generation. When we try to boost our own reputations they will surely receive a great fall. Therefore let us try to forget ourselves and not be troubled about our scientific levels. This will also save that waste of time and good paper given to polemics. When some one overlooks our writings or misrepresents them, we are apt to feel we should go him one better, which may force us into such extremes that we think we can not in honor back out. A published polemic is noisome, an airing of one's dirty linen, and springs from a condition of megalocephaly. Our work is with us, our repute with others. By being true to our work we may attain a dignity never to be reached by self pushing. Science is not a business market.

In any scientific inquiry he rightly receives the most credit who presents a definite and positive solution. Such was the case with Pasteur, in many ways the master mind of the nineteenth century; what he undertook he definitely settled. Most men attain to only conjectures, but we should seek indisputable decisions. And a good method is that of Darwin, to formulate a working hypothesis and then try honestly to disprove it. Darwin gave as full and fair hearing to the objections made against the theory of natural selection as to the evidence for it. We may approximate this by using every check and control. For we do not want the elusive possible or probable, rather the decisive actual.

But what especially lends dignity and strength is the maintenance of an ideal. German students in their expansive intimacies discuss their ideals quite openly, their "Lebensphilosophien" as they term them. We Anglo-Saxons are not inclined to talk of such matters. But a man should keep a noble aim in sight and never let it be hidden by the clouds of circumstance. That ideal must be something much grander than any detail we have immediately in hand, our several efforts only approximations towards it. We are, it seems to me, to consider the investigations of science as all directed to one end, though no man will see its consummation, the interpretation of that great melody, the universe. Here is a subject without end, all human knowledge may be employed in its elaboration. Men of the world do not understand why we are busying ourselves with fixing the exact date of the first rendering of a play, the number of times that a certain prefix occurs in the writings of Pindar, the exact length of a heat wave, or the behavior of a particular microscopic particle of one kind of organic cell. And in themselves these are not great things; an average man with patience and training might deal with them. They are on the whole so generally uninteresting that each has the world over only a small group of devotees. But when they are seen as steps in a synthesis of explanations their value is at once apparent. Our business is to weld all these separated bits of knowledge together, to make of them a great sustaining wall. And when the utilitarian inquires what will be gained by this giant effort, be ready with the prompt reply: on this knowledge depends our control of ourselves and of nature. Scientific inquiries are not to be pursued wholly academically, as games to amuse. They are attempts to explain the processes of nature, in order that we may use this knowledge for the advancement of our kind. And it is as true as the night follows the day, that explanation must precede application and consequently human progress.

This is the apology for the investigator. He has to do neither with the cataloguing and rearranging of facts, nor with their transmission, but with the enlargement of knowledge by discovery and intrepretation. Both stand for the development of character, but while the undergraduate work is for the transmission of knowledge, the graduate department is for a higher aim, its increase. If it is difficult to garner and hand over knowledge, it is still harder to add to it, and no faint heart need try to be an investigator.

Our project is to try to decipher the nature of man and of the universe, and for this there is full need of every iota of strength and determination and talent there may be in us.

THE CAUSE OF SOCIAL PROGRESS AND OF THE RATE OF INTEREST

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IT has been generally considered by the scholars of the social sciences that there is no fundamental cause in human societies for social progress. Indeed, the whole Malthusian theory is to the effect that the overwhelming rate of increase possible in human societies tends to keep a considerable percentage of the members of a society on the threshold of continuous poverty. A moral hopelessness characterizes the books of a great many economists, when they touch upon the subject of population. By reason of these gloomy chapters, political economy has been termed the dismal science.

How many established doctrines of good writers have been swept away by the light of subsequent discoveries and later reasoning! Were it not for the high improbability of any one scientific doctrine long standing without modification, I should hesitate seriously before advancing these notes on the views held by me and which are so completely at variance with the long-established and present theories of the science of political economy with respect to population and interest. Yet, because these views have greatly brightened my interest in all subjects of human history, I am interested in subjecting them to early criticism.

There seems to exist in the tendency of populations to increase in numbers the cause of progress, which, if unimpeded by certain destructive agencies, which I have termed to assist me in my thinking the "wastes of nations," would carry along on the waves of comfort and prosperity an ever-increasing population up to an unassignable limit, so great is the possibility at which a stationary state could be maintained. These destructive agencies are not a product of the increase in numbers, but they constitute the elements of the hostile environment against which progress has been continually made since the earliest historic times.

Now a social group on any habitat at a given time exists through the application of a series of arts which are possessed by the society and are exercised over the environment. The arts existing at any time may be inventoried and logically classified. The arts are productive and are ways of doing things which bring a return. There are the arts of the food supply, such as hunting, fishing, agriculture, food preser-

vation and eventually food production by synthetic chemistry in the broader classifications, of house building, of useful clothing, of hygiene, etc. These arts are known in varying degrees of detail to some members of the society.

There may be two specific arts known at a given time useful for the accomplishing of the same result. We are apt to find that art in current exercise which accomplishes the result with the smaller cost of production. It is wonderful to contemplate how very closely cost of production has been studied at all times. In the same classifications, one art successively displaces another on the basis of reduction of cost of production or saving of human effort.

But the art is very different from a material thing. The art is immaterial and useful. Wealth is commonly defined as material and useful. The art as well as the object of wealth may be possessed. The value of wealth, of the material things which are useful, is the shadow of the force of the arts, the immaterial things which create value. We must distinguish sharply some of the characteristics of the arts. Napoleon once said: "But you can not outnumber the one brain."

In a great problem, a thousand ordinary brains put to work on the same problem can not be added together. The results of all this mediocre thinking will not surpass the products of the brain of a Newton, a La Place, or a Napoleon. There is a degree or quality which can not be gained at random by addition. In the mental tug-of-war, it is true that we can not outnumber the one brain. The art is the product of the "one brain," *i. e.,* of the brain of a quality or degree slightly superior to the brains around it. We, therefore, note that a superior brain is a treasure for the community, provided the brain is put to work to solve the problems of the present life.

Now, Professor Karl Pearson and Sir Francis Galton are wont to define the exceptional man as one in a certain proportion of the population. It is assumed that in a strain of the population, there is the "one brain" in a hundred, in a thousand, in a million and in a hundred million of persons, of increasing quality for each classification. Around the lives of the "one brains" are gathered the essential narrative of the history of their times.

But, our first theorem is that the value of an art or of an invention, measured in a saving or a lessening of the previous cost of production, is theoretically commensurable, and that this value for the same new art varies with the population. In other words, the greater the population at a given time, when a new art is discovered, the greater will be the value of the art. If an art, say the invention of the sewing machine in the clothing trade, is equal to saving two dollars per capita per annum net over previous outlay, after making due allowance for new capital invested in the machine, etc., the value of the new art is plainly the

savings per capita multiplied by the population and capitalized at the proper rate of interest for new industries. If the population is one hundred thousand and ten per cent. of a fair rate for capitalization, the above example would produce $2,000,000 as the value of the invention. If the population had happened to be one million, the value of the invention would have been $20,000,000. Consequently, we note that the greater the population the greater will be the value of a new art.

The second theorem is, that the capitalized value of the old arts in current exercise steadily increases with increasing population, since the savings are effected for more people.

As a third theorem, we may assume that the new arts during any period are the products of the inventive or exceptional minds, and that the greater the population, the greater will be the number of exceptional minds of each degree for the various classifications, so that the value of the new arts during a year is the product of the exceptional minds and the average inventive productivity for each degree.

Suppose that in a population of one million, we may expect that the "one brain" in the million will produce an invention capable of saving one dollar per capita per annum over existing arts. Capitalized at ten per cent. the value of one year's product of this mind is ten million of dollars. Now, let us assume that in two million of people, we shall find two such men. The capitalized value of two such inventions as above will be not twenty millions, but forty millions of dollars. In other words, the capitalized value of new inventions for a given time tends to vary at least as the square of the population, and, if we may imagine that the "one brain" in two millions is of higher degree than in the one million of population, the value of inventions will be at a greater rate than the square of the population.

We, therefore, arrive at the conclusion that the comfort and the prosperity of a population tends to increase more rapidly than the population on which it depends; that society tends to progress under the law of increasing returns. It is also interesting to note that through the workings of our law of social progress, the per capita increment of value for arts varies with the population. In our illustrations above the savings for each person in a one million population would be one half that in a two-million population. We find in the above law an explanation of the rise in wages, inasmuch as exceptional men in all degrees tend to receive as wages or remuneration for services of the same per-capita saving a sum proportional to the total population.

All this reasoning is theoretical. The same is true of the writings regarding the Malthusian theory. But it would appear that the steady progress made in average comfort by all nations of the world since the remotest antiquity would favor the former rather than the latter reasoning. It would appear that there can be no more favoring circumstance

than a steadily increasing population, provided the quality and frequency of exceptionality are not diminishing through an untoward reproductive selection.

How carefully should statesmen strive to prevent all hindrances to the successful operation of this fundamental law of social progress which is imbedded in the very nature of knowledge. With what forethought should we strive to prevent the wastes of nations. To the wastes of nations such as disease, ignorance, vice, crime, injustice, bad government, lack of opportunity for the exceptional and war, must we ascribe the hideous catastrophes which have wrecked successively one nation after another.

On account of the above law that there tends to be an annual increase in capital value of the new arts, and varying with the square of the population, we are led to the conclusion that herein lies the cause of interest. In those fields where inventions are being made most rapidly at any time, capital is needed. The savings in part effected by the new arts are paid over for the use of the capital. The existence of an interest rate which, eliminating the element of risk, probably varies between two per cent. and eight per cent. is the shadow of this law of progress which says in substance that the product of the annual work of the exceptional men tends to vary as the square of the population, and it follows that as population slowly increases, this surplus fund comes into existence out of which interest is paid. The above, then, seems to be the major cause of interest, and many known facts are in harmony with this theory. Interest has increased historically in times of rapid invention. It rules highest in industries where new inventions are taking place most rapidly. Interest is higher in new countries where population is rapidly increasing. Further, in the case of nations retrograding through disease, vice, bad government and decreasing population, commercial interest sinks to a very low figure. The elaborate agio theories of interest seem to me to throw no light on the cause of interest. A geometrical increase of wealth, which is so universal, must have an adequate cause. I am aware that there are very many important considerations not touched upon in the foregoing, but in a series of notes, this must of necessity be so.

PARASITIC CULTURE

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IT is a fact well recognized in biology that a functionless organ is not tolerated by nature. In the evolution of life, whenever any organic structure has fallen into disuse, it has forthwith come under the law of atrophy and elimination. Until this law of atrophy and elimination is satisfied, the useless organ is a drain upon the vitality of the organism as a whole. It gives no equivalent for the support it derives from the life of which it is a part. In other words, it is parasitic. As a parasitic organ, moreover, it not only uses up energy that should go to the other organs that have a vital function to perform, but it also tends to become diseased and thus to impair the health of the entire organism.

There are numerous illustrations in the human body of the disuse and atrophy of organs, as well as of the incomplete elimination and disease of such organs. Thus there are many muscular structures, such as those of the pinna, epicranius and the platysma myoides, that are at present functionless and far on the way to complete atrophy. These useless organs are comparatively harmless, though, in strict truth, they must be nourished at the expense of the rest of the organic life. There are other functionless organs, however, that are not so harmless. Such is the vermiform appendix, in man a useless and retrogressive structure, which is apt to become the seat of serious disease. Such also are various functionless ducts, as, for example, the parovarium, which frequently become the seats of tumors, more or less malignant and destructive of life.

All these useless and, in a sense, parasitic organs of the human body, which modern research in the fields of physical anthropology, anatomy and embryology has brought to light and explained, point to laws of development that have a profound significance for every department of effort in which the control and improvement of man's life is an object. These laws are already beginning to be recognized by scientific educators. It is seen that the education of the mind and of the body consists essentially in doing what nature has been doing throughout the biological ages—that is to say, producing favorable variations through adjusting individuals to a progressive environment, perpetuating and perfecting these variations as more efficient organs of life, and getting rid of outgrown and useless organs so that no energy may be diverted

from the channels of vital usefulness. Nature is sternly and rigidly utilitarian, and yet she is splendidly idealistic. Her aim is always an enlarged, and ever enlarging, life, and to this end she can tolerate nothing in her economies that is functionless and therefore an obstacle to progress.

Here, then, is the clue that modern education is beginning to accept for its guidance. As a result, the ideal of general culture in education is being subjected to standards of criticism that are as new as is our better understanding of the nature of life. Men have believed for centuries that certain studies, or forms of discipline, have the peculiar virtue of generating in the mind, or the body, a power, or wealth of resources, that may subsequently be available for any purpose to which mental or physical energy is applied. From the days of the renaissance to the present time, universities and colleges have contended for this ideal of general culture. Mathematics and the classical languages have been regarded as, in a special sense, indispensable to such culture. In the organization of secondary schools, these institutions have been subordinated to university and college entrance requirements. And so throughout our educational system, above the elementary schools, and frequently in the elementary schools themselves, the culture ideal has largely determined the subject-matter and methods of instruction. Thus it is that in our very midst, every boy and girl who looks towards higher education in our standard institutions of learning is compelled to have certain courses in mathematics and the classical languages. Greek has at last been made an optional entrance requirement, but Latin and mathematics still hold their distinctive places. No difference what the ulterior life-purpose of the adolescent boy or girl may be, no difference what their tastes or aptitudes may be, Latin and mathematics they must have; and Latin and mathematics they must look forward to pursuing even after they enter college. All for the sake of the general culture these subjects are supposed to give!

In the light of the biological law of wasted energy and disease, in connection with organs that are parasitic on the life, we are now prepared to estimate this ideal of general culture from a new point of view. And first of all, as being more obviously amenable to this biological law, let us consider the ideal of physical culture. Now it has been contended for generations, in accordance with the general culture ideal, that certain courses of discipline will give a fund of physical energy that may be available for all the demands of subsequent life. Thus physical culture has been separated from the natural, every-day functions of life, and made a matter of general courses of training in the gymnasium. Even since the play-idea of physical culture has come to the front, and the gymnasium has had to share its prerogatives with the athletic field, much of the justification of the undue absorption of

large classes of students in football, baseball and the like, and of the over-strenuous combats waged among them, has been found in the supposed advantage of athletics in storing up a fund of physical energy for subsequent use. The line of reasoning has been the same as in connection with all phases of general culture; namely, that the discipline given, the power acquired, may be applied to all possible physical functions. In academic circles, this view of athletics, whether in the gymnasium or on the athletic field, has not even yet been very generally questioned. While the popular mind, as reflected in the newspapers, universally consoles itself for the bruises and broken bones of the strenuous athletes, with the thought that there is fine discipline in all this, and that the results in subsequent life will amply compensate for present injuries.

But here the accumulated observations and inductions of science have begun to suggest troublesome questions about this more or less artificial muscular development of boys and men. It has been observed by physicians that very frequently athletic types of manhood have weak hearts, weak lungs and weak vital organs generally. Often their health and efficiency in later life are poor; and, in not a few cases, they break down prematurely. These observations have set both medical men and teachers of physical culture to thinking, and we are now being told that there is danger of over-developing the muscular system; that over-developed muscles impose a severe drain upon the rest of the organism; and that all muscular development, unless it is utilized, becomes a tax upon bodily energy, and may give rise to disease. Only very recently a naval officer, who was an athlete while in the naval academy, is reported as having failed to meet the required tests of physical efficiency; and his physician ascribes his failure to his earlier muscular development in excess of the needs of his later life. That is to say, his vitality was reduced through parasitic muscular culture.

All this suggests that we can not store up a fund of physical energy through specially devised forms of physical training. Indeed, the term "general culture" as applied to the organic life is probably a misnomer. The culture we get from gymnastic training and from the athletic field is really special in character, and is applicable mainly, or solely, to the types of physical activity that constitute the training. Hence the energy derived from such culture does not become available for the organism as a whole, but is limited to the special organs that have been trained; and unless these organs continue to perform the functions for which they were trained, they become useless and a detriment to the life. Functionless physical structures derived through the artificial exercises of any form of physical culture thus fall under the general biological law of atrophy, with all its attendant consequences of waste and disease. The only really economical form of physical culture,

biologically speaking, is the culture derived through performing activities associated with the natural, that is to say, fundamental and long-established, functions of life. These are, in general, the spontaneous play-activities of childhood, and the productive work-activities of manhood and womanhood, each performed under normal conditions of stimulus and environment. Neither artificial gymnastics nor the feats of strength and skill performed under the stimulus of the prize-ring or athletic field come under these heads.

How such considerations have begun to affect the thought of critical students of physical culture may be illustrated by the conclusions of Dr. Jules Payot, set forth in his book on "The Education of the Will":

> The qualities of vital resistance are in no way dependent upon muscular strength. A man may be an athlete in a circus, or able to do the heaviest porter work, and yet have very poor health, while another man who lives in his study may have an iron constitution with mediocre muscular power. Not only have we no reason to aspire to athletic strength, but rather we ought to avoid it; because it can only be developed by violent exercise, and such exercises not only interfere with the regularity of the respiration, and cause very distinct congestion in the veins of the neck and brow, but they are undoubtedly weakening and exhausting. . . . We have come to the conclusion, therefore, that it is not England with her violent system of exercise which we ought to imitate in this connection, but rather Sweden who has completely given up such ruinous physical efforts for young people in her schools. There the object is to make young people strong and healthy, and they have perceived, that excessive physical exercises are more sure to lead to a breakdown than excessive study.

Turning now to intellectual culture, we have to consider whether the law of waste and disease, operative throughout the biological world, applies to the unused organs of the mind that have been developed through stunts in mathematics and the classical languages, as there is accumulating evidence for believing it does to physical organs trained in the gymnasium and on the athletic field. Here, it must be acknowledged, our evidence may seem less tangible and conclusive. It is harder, even for minds familiar with the facts of neurology and psychology, to image the special processes of nervous stimuli, the building up of cortical neurones, and the establishing of association-centers involved in mathematical and linguistic study, than it is to image the enlarged biceps of the disciple of punching-bag or gridiron education. For minds unfamiliar with such facts, it is absolutely impossible. Hence the whole process of intellectual culture, both to the average student and to the average onlooker, be he teacher or parent, has no concreteness whatever. It is a mere matter of subjective impression and *a priori* opinion. But the difficulty of our problem need not deter us. Our evidence, however intangible and remote from average experience, is sure to become clearer the longer it is considered in the light of the general scientific facts of life that are gradually becoming so extensively popularized.

To present our problem definitely at the outset, I submit the following proposition: The intellectual culture derived through standardized branches of education, as mathematics and Latin, for example, instead of having a general mental economy for the innumerable young men and women who study them, in reality becomes parasitic in the nervous and mental life, and thus is a cause of wasted energy and, possibly, of disease. This proposition has its proper qualification, of course, in all cases where such intellectual culture is so related to the functions of life that it can be utilized. There are two questions that confront us in such a proposition: (1) Is culture, unused for the specific function that called it into being, of no economy in performing other functions? And (2) is such culture, therefore, parasitic and wasteful of human energy? As has already been pointed out in connection with physical culture, it has long been assumed, and is still generally assumed, that culture acquired through any given discipline becomes a general fund of energy or skill, transferable to other organs and functions. And yet there has never been any really critical evidence in support of such an assumption. The belief in a hierarchy of culture-values, which has standardized the various branches of our academic curricula, like many other beliefs relating to the world of mind and the world of matter, belongs to the category of the naïve, the uncritical and the prejudiced. In most of the learned decisions upon the constitution of this hierarchy, the judge, the advocates, and the jury have merely reflected the nature of their own training, and more especially the interests of their own calling. But we are now in a position to submit this question to the test of exact experiments. This has been done repeatedly within the last few years by experimental psychologists. Among such psychologists may be mentioned James, Gilbert, Fracker, Thorndike, Woodworth, Judd, Bair, Volkmann and Scripture. The net result of these men's studies may be stated in the words of Professor Thorndike, of Columbia University:

> A change in one function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount that due to the change in the elements common to it and the first. . . . Improvement in any single mental function need not improve the ability in functions commonly called by the same name. It may injure it. Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case.[1]

This is direct experimental evidence, and it is fairly conclusive against at least much of the indiscriminate championship of the general culture values of special subjects, like mathematics and the classical languages. Neurology, moreover, supplies additional indirect evidence no less conclusive to those familiar with the histology of the brain.

[1] "Educational Psychology," Chapter VIII.

The study of the development of cortical neurones and association fibers makes it probable that every mental process modifies these nervous elements; so that education, whatever else it may be, is a matter of developing specific nervous organs through which the mind may work. Thus the study of mathematics means, on the neurological side, the building up of cortical neurones, with their association fibers, which shall constitute a mathematical nervous mechanism. So, likewise, the study of Latin or Greek means the building up of nervous structures specifically adapted for those languages. The clinics of nervous and mental pathology tend to show that this probable process of specialization of brain-structures, parallel with special mental activities, actually takes place. Thus when the centers of the brain having to do with mathematical relations are diseased, the subject may lose the power of perceiving mathematical symbols, or of thinking in them. So, too, when the centers of the brain having to do with language relations are diseased, the subject may lose the power of perceiving words, or of thinking in them. That is to say, the elements of mathematical and linguistic experience and culture may be lost, and meanwhile the other elements of experience and culture remain unimpaired. This would seem to prove that human experience is mediated by specialized nervous organs, and that the culture derived therefrom is special, and not general, in character. In fact, it but confirms the conclusions that all scientific students of nervous organs and of mind must reach, in any comprehensive interpretation of the facts.

Here then, is a body of facts and inferences supplied by experimental psychology, the histology of the brain, and nervous and mental pathology, which point to the conclusion that so-called "general culture" is not general but specific, that it affects organs and functions appropriate to the particular study pursued, and that to be of any adequate advantage to the life such organs and functions must continue the activity through which they were developed. There is here, evidently, a vast territory of unknown and debatable ground, but the headlands and mountain peaks stand out more and more clearly for the explorer who approaches the problems of education and life in a scientific spirit and with adequate command of scientific facts. It is clear, for example, that those educators who will subject an adolescent girl to five or six years of severe training in higher mathematics, should be peremptorily challenged as to why they do it. They should be asked to show, in terms more specific and modern than most of the vague opinions one commonly hears about "culture," just how the fund of power that is supposed to be generated by mathematical study, is, in fact, generated; and how it becomes available throughout the girl's subsequent life. So, too, these same educators should be asked to give reason why they compel an adolescent boy to spend five or more years upon the study of Latin before they will accredit him as being educated.

What is there in this comparatively immense expenditure of time and energy upon Latin that will develop organs and functions continuously available for the boy's mental efficiency and usefulness in the world? How does a nervous mechanism, with its infinitely complex system of neurones and connecting fibers, fashioned through and for the study of the Latin language, become adapted for all other mental processes? In short, it is time to read a new and compelling significance into the old query of instinctive common sense as to what is the value of the so-called culture that is doled out to our children in the secondary schools and colleges.

Having thus answered the first question involved in our proposition, it remains to consider the further question of what becomes of useless organs of culture. What is the effect upon the girl's life of having to support an elaborate nervous mechanism for dealing with mathematical symbols and concepts which she never has occasion to use? What is the effect upon the boy's life of having to support a nervous mechanism for declining Latin nouns and adjectives, conjugating Latin verbs, and construing Latin sentences, which he never has occasion to use? May not these unused nervous organs become parasitic upon the nervous vitality, just as the unused muscles of the athlete become parasitic upon the general organic vitality? It may seem to some little less than fantastic to suggest such a result. And yet, if we believe that life is a biological unit, and that the laws controlling it are identical in nature and operation, there is no escaping this conclusion. Moreover, there are many peculiarities in the nervous and psychic constitutions of a considerable number of educated men and women that await a plausible theory to account for them. The suspicion is harbored in many minds that academic communities are apt to become over-cultured. They are apt to lose that balance between perceptual and conceptual experience which is the supreme test of healthy-mindedness. At the very best, they suffer from an hypertrophy of the critical faculties, which reveals itself in philosophical and linguistic hair-splitting. At the worst, it may amount to a nervous tension and general intellectual straining after precision in scholarship and propriety in conduct that creates an atmosphere blighting to spontaneity of work and life in the students. This is frequently illustrated in schools and colleges for girls, where an excess of women teachers, with hypertrophied intellects and atrophied human interests, make education a process of mental arrest and disease instead of growth.

Outside of academic communities, there are to be found everywhere a cultured flotsam and jetsam. Europe has long had its proletariat of culture, and America is rapidly developing one. In the more intense nervous life of America, moreover, there are appearing numerous types of nervous instability among educated men and women. This is illustrated not only in the frequent neurasthenia of the cultured classes. It

is also, and, perhaps, more characteristically, shown in the religious, social and other vagaries that often bring to light strange perversions of human energy. The movement towards the emancipation of women during the past few decades, with all its numerous and positive merits, abounds, nevertheless, with examples of mental and emotional distempers that find their psychological explanation in the strangulated intellectual energies of its votaries. Much of the current unrest among intellectual women is probably due to specially cultivated mental organs that find no adequate function to perform. All these forms of neuropsychical strain and instability are, I submit, at least partially explicable in terms of the useless and parasitic culture, which has become more dangerous to modern society in proportion as it has been extended to the masses of men and women. In earlier generations, when fewer men and women were subjected to the artificial culture of the schools, the general detriment to society was not so obvious. But now that thousands and tens of thousands of boys and girls, and young men and young women, are having their nervous and mental lives fashioned for activities they never have a chance to perform, it may happen that higher education, instead of being a means of racial advancement, will become a means of racial deterioration.

To summarize:

1. It is a law of the biological world that unused organs become parasitic upon the life, draining off the energy of the individual and tending to become diseased.

2. It has been found that physical culture which leads to the hypertrophy of special muscles, entails a drain upon the general vitality. As in life in general, so in physical education, organs that can perform no adequate function are wasteful of human energy.

3. Experimental psychology is showing that the culture of particular intellectual organs and functions can not be transferred to other organs and functions, except where there are elements in common. Histology and pathology of the nervous system confirm the conclusions of psychology in this respect.

4. Intellectual culture not being transferable must become parasitic and a cause of mental disorganization when it fails of application and usefulness in the life of the individual. Illustrations are to be found in the over-refinements of culture in academic communities, in the nervous instability frequently met with among educated men and women, and in the religious and social vagaries and perversions that crop out in the older and more highly cultivated centers of population.

5. The artificial culture of the secondary schools and colleges in our democratic society, in proportion as it is diffused throughout larger sections of our population, is likely to develop a cultured proletariat, ill-balanced and inefficient as individuals, and a source of danger in our civilization.

CENTRALIZED AUTHORITY AND DEMOCRACY IN OUR HIGHER INSTITUTIONS[1]

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IT is somewhat embarrassing to appear on a program that I myself have assisted in devising. It demands an explanation. It is, in short, an instance of too highly centralized authority in this association in the hands of our lively general secretary. It seemed eminently desirable to the committee that this topic to which I am to address myself should have consideration. When the first draft of the program came into the hands of the secretary, with a blank left after this topic, he rashly placed my name after it, rushed to print and scattered it broadcast over the country. So I am here against my will but, I must confess, not wholly reluctantly. The topic is of immense importance. It was a vain endeavor to find the proper person who should address you on this theme. All presidents and all who aspire to such position of power were condemned to silence from the start. That cut off the flower of the genius of the nation at a single stroke. The presiding officer of our department had an intimate way of knowing that presidents, being under indictment, so to speak, could not be trusted with the topic. There has been much written and spoken latterly on the theme, but mostly by those whose ambition has been punctured, whose pride has been stung or whose wings have been clipped. Were any of these turned loose in this place, they might enact a bloody scene not entirely consistent with the proper spirit of a *religious* association. Our general secretary must have known that I had no ax to grind, no grievance to right, no power except the power of righteousness to fear, and that I should speak in a wholly guileless manner. It is a temptation to admit that this was another instance of his rare insight; for however much my judgment may be at fault and wisdom limited, I shall address myself to this most delicate topic entirely without animus. I might follow the example, indeed, of one of our periodicals which recently declared that, with a single exception, theirs was the only sheet in the nation that is not subsidized. If I lay claim to being, with but an exception or two, the only mind in the nation that is dispassionate on this question, then every member in the audience will congratulate himself that he is that other person and we shall all be thinking through the subject helpfully to one another.

[1] Read at the meeting of the Department of Universities and Colleges of the Religious Education Association, Nashville, March 9, 1910.

There can be no question that American universities and colleges are highly centralized in respect to their organization and control. The power legally is in the hands of some kind of a board of education, mostly composed of business and professional men who are in no sense organically a part of the institutional life of the university. Practically, the power centers in a president and faculty. In all matters that refer to the running of the institutional life of the place, these are autonomous bodies. They make their own laws; set their own standards; inflict their own penalties, and exercise their influence without asking anybody any questions. Their constituency, so to speak in state and church has little power. President and faculty are considerate of their constituents—sometimes tenderly so, when the budget is in excess of the available means, or when the normal percentage of increase of attendance is not attained. Otherwise these good people are expected to be silent well-wishers. Perhaps that is as it should be; at least I see no way to change it. Our chief consideration at this time, however, is that *students* have almost no voice in the control of the institution they attend, little feeling of responsibility for its destiny, almost no sense that their personalities are caught up into it, or that they are an organic part of its best life. The ordinary student feels himself to be an attaché, a recipient, an appendage at best, and lucky for him if he is not a sort of parasite—a foreign body, drawing vitality from the institution for a time and then going away with it. If I am right in believing that the ordinary student has a sense that he is a sort of inmate of the institution, who must obey the rules and get what he can; who does not have a stimulating sense of partnership in the place; who can talk with zest about *my* fraternity or *our* team, but who never can talk with the same warmth about *our* college spirit, or *our* curriculum, or our faculty, or our institution; if the bulk of students at the end of the four years' course have any feeling deep down that the center and core of their own wills are aloof from the deepest, warmest currents of the institutional life, then something is wrong; for the university exists solely for the student—indeed, it has no other reason for being. I fear, however, that our universities have become bulky institutions that exist chiefly for themselves—to perfect their own machinery, to preserve their own lives; they are closed systems busy with inner adjustments, rather than with the problem of how they can cultivate the soul-life of those entrusted to their care, and burning with a passion to be of service, through the students, to church, state and humanity. Our higher institutions have been developing, during recent decades, rapidly in the direction of an imperialistic attitude toward students. Professor Stratton, who first set our minds going in a lively manner in this direction, points out the anomaly existing in our political ideals and our university practises, and also the anomaly of anomalies that

Germany reverses the inconsistency, being politically imperialistic, but educationally democratic. Speaking of our own nation he says:

> Among a people so jealous of private rights, university governments have assumed a form that we might have expected to see in a land of kings. European universities have a constitution that might have come from some American theorist. American universities are as though founded and fostered in the bourne of aristocracy. Europe and America are each harboring what would seem properly sacred only to the other.

There are four or five causes that have brought about too great a centralization of authority in the hands of president and faculty, and along with it a cleavage of interest of faculty and student body until they stand off from one another in a relationship that is not wholesome for either.

1. In the first place, a historic strain of autocracy has come down from the old-fashioned schoolmaster. In the early days of America, the schoolmaster, with rod and rule if need be, usually a man—not a lad of eighteen or a woman or much less a frail girl—was a monarch in his realm. He was built, and for a reason, on the lines of a sturdy, stern Anglo-Saxon father. He has left us as a heritage his custom and conception of imperialistic authority in education along with his ineffaceable three "r's." The secondary schools were differentiated from the common schools. The "head master" developed out of the parent stem, the schoolmaster, under the rule that like produces like. He was well named, for he was expected to be superior in wisdom and masterful in bearing. The college is a specialization of the old academy and high school, and has inherited from these many of its ideas about curriculum, form of organization and centralized authority.

2. In the second place, as Professor Stratton has pointed out, our higher institutions have received a strain from the form of government of the early colonies. These were under the rule of the mother country, which rule was effected through a corporation, or a governor, or both. They were never elected by the colonists nor selected from among their number, but superimposed on them from the mother country. Our boards of education are descendants of the early corporations, and the university presidents are built after the pattern of the early governors.

In imperialistic Europe the democratic life of the faculty and the university generally, on the contrary, is the direct historical consequent of the old guilds that were established around the idea of equality, fraternity and mutual helpfulness.

3. In the third place, the higher institutions have reaped the blessings and also the ills of the naïve democracy in which each individual is turned loose to do as he pleases, and, being human, chooses to be unduly self regardful. There are many indications that the earlier colleges, established by people whose passion was for equal opportunity,

incorporated unconsciously and as a matter of course, much of the spirit of democracy into their organization. The spirit of common fellowship often pervaded the life of the faculty and students. They were intellectual brotherhoods like families or fraternities in spirit. The gradual, quiet transformation that now has made of them, perhaps, the most imperialistic educational institutions in the world is not so difficult to account for. This has been a land of freedom and opportunity. There have been all kinds of things lying around loose in America—virgin soil, virgin forests, virgin mineral lands, virgin society and virgin politics. The liveliest and strongest have gone after the benefits, appropriated them, taken means to hold possession against the covetous, and then, alas! have found themselves unwittingly, as a result of wealth, social preferment and political power, proud, arrogant and irresponsible, and pitted against their fellows. Those who have not been lucky themselves have nevertheless had something of hero-worship in their veins. They have admired Napoleonic success and Anglo-Saxon strenuousness. They have passively paid tribute and so have had their part in the immoderate inequalities that have sprung up. The inevitable outcome of it all has been a harvest of captains of industry, captains of wealth, captains of politics and captains of education.

Do I dare say aught in this place about college presidents? If so, it would be in the "spirit of sweet charity." They have had their temptations and trials; they are subject to weakness of the flesh; they have been battered and buffeted, and whatever is said about them must be spoken in kindly sympathy. They are not vicious, they are not "exploiters of genius"; they are not worshippers at the shrine of mammon, nor devotees of the God Thor with his symbol of the arm and hammer; they are just human. Like all of the other citizens in our primitive republic, with its free opportunity, they have seen a good many things lying around loose. This time it has not been some irrigation stream or mineral deposit that they saw lying unclaimed, but the opportunity for power. No one else had been exercising it, and why not they? Indeed, they have gathered of the treasure in large measure, and why not? Men do love power if they are normal. There is no better thing in the moral order than a will that can produce, create and help things along. There is not a more righteous joy than the feeling of that fine tension of a strong will that can be a living force in the world. But enough is a sufficiency, and too much, even of a good thing, is dangerous. And men are human. Let us say, with gracious compassion, that it is the fault of the times, of our social order, that has placed in the hands of presidents the power of life and death over the professional career of members of the faculty and also the shaping of the destinies of our educational institutions.

Members of faculties are also human. They have acquired all the power that has been relegated to them by constituencies and boards of education, and have picked up whatever else they could acquire on their own account. They have sometimes watched their chances to share the responsibilities of the institution with the president, lest it should weigh too heavily upon him. Some one has happily said that no Irishman could be found in Ireland so poor but that he has not some other Irishman dependent upon him. Presidents and faculties together have come into the position of almost entire separation from the student body. They have the attitude of ruler and ruled. They march in stately parades, begowned in robes of dignity and state before the admiring eyes of the students; they run the institution; they dispense grades and degrees as parsimoniously as possible to students who devote their college career to earning these marks and badges as economically as possible.

4. In the fourth place, competition has played its part in bringing about centralized authority. It has been necessary for institutions to act and act quickly in the raising of funds, in the employment of instructors and in appeals to the public. The matter of winning out in the contest has led us to do much as a hive of bees in creating a queen. We have done everything in our power to produce presidents who are masterful, who can appear well, who can be "drawing cards" in tempting into our institutions the guileless youth of the land. There is no one who will dispute that our university and college presidents are of the noblest of our people. But we are creating them at too high a cost. It is the fundamental axiom of our entire educational system that the end is not so much to produce leaders as to lift the level of all. It is growing too late in the history of democracy in the world to need to argue the point. Still an analogy will be in place. Christianity, during the first century, was a spiritual brotherhood. In the second and third centuries, they began to have conventions, and it was the custom for a bishop and at least one layman to represent a church or diocese. By the fourth century, the laymen had been almost forgotten in their councils; and from that time on the power became more and more centralized in the hands of a few of the highest officials of the church. The consequence is a familiar fact of history. From the fifth century, for several centuries following, the organization of Christendom was a closed system with neither change nor progress. It existed not for mankind as persons, but for itself and its own institutional ideals. In our educational system the laity, the students in our universities, have long since lost their voice. Our educational elders, let us say, that is, members of faculties, have been little consulted in our national association of universities that are taking upon themselves the right to determine the educational policies of the country. We are living in a

later age, and must not allow the history of the first five centuries to repeat itself.

The spirit of competition has magnified out of all proportion the value of quantity instead of quality. Bigness has bred looseness of organization and aloofness of person from person and group from group. The tendency toward manifoldness has been augmented by the natural law of differentiation, of which specialization is an instance, until our institutions are atomistic. Each person has relegated to everybody else all responsibility for everything except his own little sphere of interests. This differentiation amounts in the long run to radical individualism and approximates indifferentism, the worst disease that can affect the life of higher institutions. The only excuse for the large university is that it may have a more highly organic and intense life than a smaller one can have. Growth at the expense of inner coordination, refinement of articulation and intensification of the individuality of the whole, is a disease, whether in plant, animal or institution. We have grown like a boy in his teens as fast as our health would allow. The rapid differentiation in general has naturally widened the gap between student and faculty, who are made for each other like eyes and hands. The next step, in order to get safely through our stalking educational adolescence, must be in the direction of binding up into the life of our colleges again, the personal lives of students.

5. Still another fact must be mentioned that has made of our faculties against their own will, ruling or governing bodies who are set off against a pack of persons supposing themselves to have antithetical interests to those of the university as an institution. Through the hasty expansion, already referred to, the machinery of the university—teaching, looking over papers, grading, giving credits, establishing standards, etc.—has grown into such proportions that there is little time and energy left for anything else. The enforced result is that the prevailing point of contact between students and instructors has come to be in terms of their proper advancement and grading in the curriculum, and what they must and must not do while resident in the institution. I appeal to those present who have spent a number of years as instructors in colleges and universities whether nine tenths of the time of the faculty meetings is not given up to such questions as marking systems, giving of grades, granting degrees, penalties for delinquencies, admission and classification of students, control of athletics, regulation of social affairs, and the like, which have nothing to do, except indirectly, with the inner personal life of students. From the University of Plato in Athens, Plotinus in Rome, Abelard in Paris, and the College of Mark Hopkins in America, we have traveled far. We catch glimpses in the New England days of what was called among professors, a hunger for the souls of students. Those days will never

return; but we have suffered a loss that is irreparable, if there is not preserved in our colleges and universities the equivalent of the things they did, as shown in reverence for the divine beauty of personality in the lives of our students.

There can be no question but that our attitude toward students is conventional, mechanical and institutionalistic. Behind us, to hold us firmly in our chosen course, besides the causes we have been describing, is the wish of anxious parents who forget that their young men and young women are not still children and who say gracious things about their favorite institution if their sons are held in check, and if their daughters are tenderly "guarded" and pampered.

What are we to do about it? How can the student body and faculty be brought into closer relationship? How may our universities escape a cold institutionalism? What changes will move in the direction of most surely catching up the personal loves and enthusiasms of the average student into the warm, vigorous, purposeful life of the institution? There are many things to do, certainly. I shall confine myself to a simple urgent suggestion that leads, I believe, towards the heart of the situation. The spirit of democracy should prevail. Not a sentimental democracy that preaches equality and cooperation, and practises autocracy. *Students should be given a part, however small, in the control of our institutions.* It is not my purpose to determine specifically what their powers should be. That has been so delightfully and convincingly discussed in the paper preceding my own that nothing further need be said. It is in itself a suggestive fact that Professor Fiske, like every one I have met who was connected with the Amherst attempt at self-government, believes in it thoroughly. Indeed I know of no one who has observed intimately any of the various experiments in student participation in student affairs, who has for it other than words of commendation. My contention would be that the kind of thing students undertake is more or less indifferent, if only they feel that it is worth doing and that they do it with a will. It may be the matter of honor in examinations. Students can do this successfully, as several happy instances prove, while instructors are powerless to cope with it, except at a cost in moral and social attitudes toward students that is hopelessly disastrous. Let it be the regulation of social activities, over which faculties distress themselves and still do their work so bunglingly that students wink at it and smile at their own cunning. In some institutions students have undertaken the control of the daily paper, monthly literary sheet, and a comic sheet, from which they learn the meaning of free speech and the virtue of controlling it, derive lessons in collective ownership and the joy of building for the future. In some instances they have been given a controlling voice in athletics, with advantage to the spirit of the institution. One spontaneous

impulse of students toward pure sportsmanship that grows out of facing a concrete situation with responsibility is worth a half dozen lectures by a professional moral dictator. These are only instances of the many possible lines along which student activity may express itself. President Drinker, who has, with remarkable success, encouraged self-government at Lehigh University, says: "It has been my experience that the more responsibility is placed upon students, provided they are willing to assume it, the better it is for all concerned." Even a small duty that students enter upon heartfully is enough to transform their attitude into one of partnership. It is an old rule that interests follow activities as the shadow the body. Sympathies and enthusiasms apart from deeds are pale and shallow. When students undertake anything in concert they must have organization. This creates unity of action and solidarity of sentiment. The fact of positions of emolument to be filled and the need of officers, leads to college politics with its fine tension of rivalry and its tang of victory and defeat. Let us grant there will arise occasional abuses and mistakes. There are instances on record. The number is, however, relatively small. The redeeming feature of it is that whatever failures and successes they make, there is in it a preparation for citizenship. They are meeting in college life exactly the problems and difficulties that they will have to face later. We preach the gospel of learning to do by doing in the lower grades of our common schools, but are full of the notion of the value of learning to do by obeying, during the choice years of young manhood and womanhood, which are above all others the time for preparation for the duties and responsibilities of citizenship. The educational world has had its prophets this long time of the value of social and family ideals among tiny children; but by a strong irony of fate, we have been slow in taking seriously the same problem during the critical formative years of a college course.

The root of the difficulty is in the need of more democracy in our institutions. That would come in a day if all concerned could apply the golden rule. There is a sort of mental near-sightedness in human nature by which it is hard to see through the other person's eyes and feel his problems. All are, furthermore, intensely human—biologically human—and want all they can get of power and prestige. Universities have differentiated into about four types of personages: a board of education, a president, a faculty and a student body. All except the last would dominate everything if it could. The best results will come only when each participates slightly in the whole, but specializes upon its own function. The board are specialists upon finance and should exercise a fairly free hand in all the material interests of the university, with only a negative control, through the power of veto, upon scholastic affairs. The faculty are specialists upon institutional questions. All

matters of the formation of the curriculum, standardization, election and dismissal of instructors and the like, belong naturally to the faculty, with board and student representatives, under normal conditions exercising advisory influence. It is as hazardous for boards of education to assume responsibility for the complicated institutional life of a university and exercise the fine shades of judgment needed for its success, as it would be for the ordinary university professor without the requisite years of preparation to run a bank or department store. The president should be chairman of the faculty. His proper function is primarily an executive one, and in no sense legislative or judicial. But the prerogatives of students—what are they? I recently asked a professor in a state university what power, in his judgment, students ought to have in an educational institution. He replied, "Power? Why, the *power* to work and work like thunder." When I argued that they were already in possession of such freedom, he retorted emphatically, "But they do not seem to know it!" No one has to urge a graduate student, interested in his problem and inspired by personal contact, to work. Usually, on the contrary, he must be restrained from too continuous application on account of his bodily health. His attitude toward instructors, tasks and institution is different. Student bodies have rarely come into possession of their own. Why should they not have full responsibility for student enterprises and social activities? How much power of the faculty, which is legally the responsible agent in such matters, should be in evidence, is an open question. Professor Payne, of the University of Virginia, where for more than a century students have successfully regulated questions of student honor, honesty and propriety, assures me that the plan is working well, just because the faculty keep their hands off entirely. Under such circumstances students are glad to regulate their own affairs, and they do it well. I know of no instance in which students have participated in the activities of an institution, wherein they have broken faith or usurped power. Still they are treated as underlings, while instructors keep school, hold examinations and administer grades. Under present conditions they are filled with ideals of military discipline rather than infused with social impulses. Why may not our universities be transformed into states in miniature or social communities, in which students are "the people," each of whom is tempted by the entire situation, to care, to lend a hand, to feel the thought currents of the time, to know men as well as books, to be efficient units in society? In this direction we must tend if our new ideals of social righteousness are to be woven into the texture of our common life.

The problem would be easy were we not tempted by the luscious sense of power and blinded by a highly developed institutionalism. The university exists for the students, and not the students for the university.

No one would care to depreciate the conservation of race life that is accomplished through the mere fact of the existence of a group of teachers, a body of college customs, and well-equipped laboratories and libraries. But they are not finished products. They are means to an end in a living, growing organism. The end is the best life of all and the fullest life of the future. There is a distortion when the rich inheritance of the past that the university represents is not directed wholly and purposefully toward the students who are to be the race of to-morrow. To this end the university may well exert itself to have them feel that they are organically a part of it. Each student when he goes out should be, not a recipient from the institution, but a real incarnation of its best life. He must be in it and of it. The form of organization should tempt him into closer and closer heart relation with his school. Let it not be, either, a seeming act of charity or missionary enthusiasm on the part of instructors, or the best is lost. The advantage is mutual. Each student has some original endowment from nature to bring to the institution. I have heard it sometimes expressed that part of the fascination of the life of a teacher is in the personal enrichment and the multicolored quality of truth that come from mingling with many types of student minds when each is allowed to be at his best. In order to bring out the riches of his nature, generally as yet undiscovered even to himself, the attitude of the university toward the student and his attitude are almost everything. It can not reach him from the outside in; it can inspire and educate him only from the inside out. Let our universities be decentralized from their organization about institutionalism, and recentralized in the personal lives of students.

THE FIVE-FOLD FUNCTIONS OF GOVERNMENT

By W J McGEE, LL.D.

I

ORGANIZATIONS, like organisms, are products of development. Governmental organizations, like most others, are increasingly designed and shaped in the light of conscious experience. Thus, the constitution of the United States epitomized the lessons of history so far as recognized by its framers, whereby the instrument became the embodiment of governmental practise and theory gained through known experience. Naturally, by reason of the ability of the framers and the stress under which they wrought, the instrument is notable—certainly among the most notable ever produced, whatever be thought of Gladstone's view as to the divinity of its inspiration. Naturally, too, the framers specified most clearly those governmental powers with which they were familiar and which they most desired to adopt: and, no less naturally, their action was guided quite as much by the wish to eliminate that which they thought objectionable as by the aim to perpetuate that which they deemed desirable. Seeing that government is an expression of law, their first care was to provide for the framing of laws, the second to provide for the execution of these laws, and the third to provide for the interpretation of law; and in this way arose what came to be known as the "three coordinate branches" of the United States government. The branches are indeed coordinated, though they are far from coequal, since the power of creating the third is entrusted to the second "by and with the consent" of a part of the first; yet they by no means constitute the entire government—as becomes clear in the light of earlier phases of social organization made known largely since the instrument was framed, no less than in that of discussion before and during the framing of the constitution.

Early in that primitive social type in which tribal organization rests on consanguinity traced in the female line, the elder-woman is both lawgiver and judge, while her elder-brother acts as an executive in case of need, and the two jointly or severally exercise administrative authority throughout the clan; later the elder-women become priestesses or seeresses still giving and interpreting the clan laws, and their elder-brothers form an avuncular council of gradually increasing executive and administrative powers; yet at every step all primary power is imputed to a mystical pantheon of which the beldames are only vicars and the sages merely indirect agents. In the next stage of development

(*i. e.,* in the patriarchate, in which organization rests on consanguinity traced in the male line), the elder-man becomes vicar or priest, and hence law-giver and judge as well as both administrative and executive —as when a patriarch communes with his deity over sacrificing a son or daughter, or a kalif commands of his own impeccability, sits in judgment, awards and rewards, imposes and deposes, and (like a later emperor) personifies the state; yet his primary power is imputed mainly or solely to that supernatural source of which he is deemed but the agent. With the growth of cities and those civic usages in which the organization arises in proprietary right (especially in lands), rulers long remain vicars of mystical or spiritual powers manifested in symbols and ceremonies though often exercised through arms and armies; and until within recent centuries each monarchy was virtually a hierarchy whose king or emperor stood—panoplied in the "divinity which doth hedge about a king"—as the source and exponent of both temporal and spiritual power, performing so much as he would of all governmental functions, his rule ranging from hierarchic to autocratic according to the faith and custom of the time. Gradually (the rate being vastly accelerated by the American Revolution) the monarchs surrendered legislative functions, delegated judicative powers, divided administrative and executive duties with the agents of parliaments and courts, sometimes shared their vicarial powers with ecclesiastic potentates, and began yielding to the inevitable growth of petition into suffrage; yet no monarch was ever quite independent of putative supernatural powers residing within or conveyed through his own personality, or of the symbolism or ceremonial tending to perpetuate the imputation.

In brief, during each stage of governmental growth from the simplicity of primal clan to the pomp and circumstance of gilded empire, the primary functions remain much the same despite sweeping changes in structure. In logical order the functions are (I.) initiatory, and (II.) directive, the former connoting the source and the latter the aim or control of institutional power. In genetic sequence, or in that order of successive manifestation illustrated, *e. g.,* in the natural family of which the clan, gens, city and nation are outgrowths, they are (1) *administrative,* or concerned with the current regulation of every-day affairs; (2) *legislative,* or concerned with the establishment of rules of conduct (always finally adopted only through common consent); (3) *judicative,* or concerned with the peaceful settlement of disputes in accordance with custom and established rules; (4) *executive,* or concerned chiefly with the carrying out of rules and judicative decisions; and as the natural source of power gradually comes into ratiocinative view in the light of the general good, (5) *determinative,* or concerned with the primary expression of common judgment and desire.

Now when the founders of the American nation undertook to frame

a governmental organization, little was known of the natural stages in the course of human development. The notable works of Maine and McLennan on primitive law, of Fustel de Coulanges on "The Ancient City," of Lewis H. Morgan and Herbert Spencer and Auguste Comte on early society, and of Taylor and Powell and Brinton on lowly religion had not been written—indeed the epoch-marking investigations of these and other writers run back to the unprecedented efforts of the American revolutionists to ascertain the ultimate foundations of human government, efforts not disparaged but only accentuated by the rapid growth of human knowledge since they were made. Since then, science has come into being on the earlier foundation laid by Bacon and Linne and a few others: of the five cardinal principles of science,[1] the first (the indestructibility of matter) was established by a contemporary of the Revolution, Lavoisier; the second (the persistence of motion) grew out of Rumford's experiments begun under the influence of this American rennaissance; while the others (the development of species, the uniformity of nature, and the responsivity of mind) came scores of years later—indeed nearly all of the current branches of science have arisen since the revolution. Since then, too, historical knowledge has been both expanded and refined; geographic knowledge has extended over the full half of the earth then practically unknown; invention has revolutionized industries, largely through the American example; steam and electricity and high explosives have been harnessed; the world's population has doubled; man's conquest over nature has advanced further than during all earlier time; statecraft in the modern sense has taken form, and diplomacy has been reconstructed, both largely through the world-touching influence of the seventh and eighth decades of the eighteenth century; and the American governmental model has been adopted in spirit if not in form by far the greater part of the nations of the earth. In the light of the vast advance since 1776, the sagacity and courage displayed by the signers of the declaration and the articles of confederation, and especially by the framers of the constitution, shine forth among the greater marvels of human history.

The founders included eminent scholars and statesmen, yet they were practical men confronted by problems of which the issue meant life or death; and on surveying the field of experience in governmental organization within their reach, they seized on the essentials and wisely withheld their hands from both the collateral and the controvertible. Dwelling long on the pressingly practical (as shown by the record of discussion in the constitutional convention), they defined clearly the legislative and executive and judicative functions of the nascent gov-

[1] Outlined in an address of the president of the Anthropological Society of Washington, delivered before the Washington Academy of Sciences and affiliated societies February 19, 1900 (*Proceedings of the Washington Academy of Sciences*, Vol. 2, 1900, pp. 1–12).

ernment, leaving the then relatively unimportant details of administration—over which controversy arose whenever the subject was approached—to the sense of their successors; while they proceeded so circumspectly as to reveal implicitly rather than by explicit statement their chief—and history's greatest—contribution to governmental principle, *i. e., the substitution of human power exercised through an electorate for the inscrutable might manifested through a hierarchy* as the basis of government. Strong as is the constitution in every feautre and department, its chief strength lies in that last-written but first-placed paragraph, "We, the people of the United States, . . . do ordain and establish this Constitution." With this utterance the mysticsm of the ages fell away, and the foundation of humane government became fixed forever; and the new light has already gone around the world and entered every land.

Now in addition to the specific powers expressed in the first, second and third articles of the constitution, others are so clearly implied or expressed *inter se* that they were unhesitatingly exercised from the day the instrument was adopted. These embrace the administrative power implied throughout, together with that primary power ranking all the others combined (since they rest on and arise from it), *i. e.,* the determinative (or elective) power implied in the first, second, fourth, fifth and sixth articles and expressed in the preamble. So any complete enumeration of the powers of our government (or any other of representative type) necessarily comprises those pertaining to the five innate and coordinate functions involved in all governmental organizations from the most primitive to the most advanced; in logical order—which is that reflected in the constitution—they may be denoted (1) *elective,* exercised by the people; (2) *legislative,* exercised by the congress; (3) *administrative,* exercised by the president and his cabinet officers; (4) *judicative,* exercised by the court, and (5) *executive,* exercised primarily by the president.

II

The popular movement for the utilization of our waterways[2] first marked an awakened public sentiment; now it is stirring the national conscience in a manner not unlike the movement of 1776. A round century of public indifference since Gallatin followed Washington in pointing a way, and a half-century of national incompetence attested by the decline of river and canal navigation—these unwittingly set the alarm now ringing. As befits democracy, the awakening began with the extremities of the body politic; yet signs are not lacking that it is reaching the somnolent centers. When the declaration and the con-

[2] Described in "Our Great River," *World's Work* for February, 1907 (Vol. XIII., pp. 8576–8584), and "Our Inland Waterways," POPULAR SCIENCE MONTHLY for April, 1908 (Vol. LXXII., pp. 289–303).

stitution were framed, the sense of citizenship still lay dormant in all but a few leading minds, and in some of these soon turned sluggardly for longer slumber; then the legion prodigals were fed with the swine on husks of party welfare rather than the sound corn of public weal until a shadowy "no-man's-land" grew up between citizen and state and a "twilight zone" spread between state and nation. Yet, stirred at last by the waterway movement and a forest policy uniting in the cult of conservation, the people are at last preempting the shadowy middle ground, and thus coming into their own as citizens. Two years ago the governors—the actual sponsors for the welfare of their commonwealths—felt the stir; they responded vigorously, and now they and their people are moving together against a tyranny of regnant apathy not greatly different from that of his ease-loving and privilege-giving majesty George III.

Within a few months the congress began to respond to the popular demand by authorizing the publication of the reports of the Inland Waterways Commission and National Conservation Commission and the Proceedings of the Conference of Governors; then the senate created a strong committee on the conservation of natural resources; and within a month this committee reported favorably a bill for the establishment of a "National Commission for the Conservation of Natural Resources." The report[3] meets the popular movement half way. Declaring that "The measure is designed to conform with various actions, both legislative and administrative, growing out of one of the strongest popular movements in the history of our country," the document outlines the movement, summarizes the nature and extent of our natural resources, indicates the leading wastes and the industrial diversions attending development of the resources, and concludes with a plan for action framed to meet the people's will. Even more significant than the body of the report is the appendix; for at last the senate has yielded to the voice of the people sufficiently to print the expressions adopted in great conventions of citizens—among others, the declaration of the Fourth Deep Waterway Convention (adopted in New Orleans November 2 last) "comprising duly appointed delegates to the number of 5,000 from 44 of the 46 states of the union, including the governors of a majority of the states," which finally turned over a new leaf by recognizing and declaring the rights of citizenhood to "demand and direct" action by their representatives—in lieu of the far lesser rights of subjecthood to "petition" or "submit" or "respectfully request" or "forever pray" with which Americans have been content for a century —and then nailed down the new leaf by the public pledge of personal honor proper to full citizenship! Surely if these 5,000 delegates mean

[3] Calendar number 733, Sixty-first Congress, second session, Senate Report No. 826, pp. 1–50; ordered printed June 11, 1910.

what they say—and who can doubt their sincerity?—no more significant utterance has been made on American soil since the declaration of July 4, 1776. The final paragraph of the declaration reads:

> Believing in our hearts that the needs of the country and the fundamental principles of our government set forth herein involve moral no less than material issues, and agreeing that the time has come for us and the other citizens we represent to exercise our constitutional powers by the means provided when the constitution of the United States was framed, we, the delegates in this convention assembled, representing more than half the people and three fourths the productive energy of the United States, do hereby deliberately and firmly, and in the full realization of our duties and responsibilities, demand and direct that a definite and vigorous policy of waterway improvement, beginning with the Lakes-to-Gulf Deep Waterway, be adopted and put into operation by the national government without delay. To the enforcement of this demand we pledge our individual effort and our united support; and we hereby publicly pledge our personal honor, each for himself and to each other, to support no candidate for public office who will not unqualifiedly indorse and maintain that policy.

Academically, such an utterance is in so full accord with the constitution and with the principles of popular government as to be commonplace; yet actually it is so far out of accord with current governmental methods that the third of the representatives and senators in attendance at the convention generally (except perhaps a dozen progressives) repudiated and condemned the utterance more or less openly as "socialistic" or "anarchistic." Still the voice of the people has echoed and reechoed; and at last it has reached print in a public document.

The spirit of the Lakes-to-the-Gulf Deep Waterway Association expressed in their declaration has cropped out in various conventions other than those noted in the senate report. During the past two years the question has been growing more and more incisive, Is this nation competent to protect the interests of its people? The question has been pressed in non-partisan assemblies held in every section, including citizens of every state, and with constantly increasing directness and pointedness; and it is a sign of the times that it is put with a sense of power and a realization of responsibility unprecedented in the century and a quarter since Washington moved toward the constitution. America—the collective mass of ninety million souls—is a long-suffering if not lethargic giant, slow to wrath and show of strength; yet as to its power when aroused—who can doubt? Its full strength lies in the spirit of the ninety millions; the force of a first effort lodges in some eighteen million voters, a half temporarily tied by one special interest or another—but nine millions are full freemen, and five millions more are ready to follow their lead. Now that the giant is aroused, in conscience no less than in sentiment, the demand of the people is attracting attention. Already the waterway advocates can point to a partial re-

sponse to their demands in enlarged provision for river surveys, in provision for a national waterways commission empowered to extend and apply plans framed by the last administration, and in a recent declaration of the administrative and legislative authorities that "pork-barrel" appropriations must cease—indeed, to the longest steps in the right direction since Washington prevised and Gallatin planned and Windom pleaded for rational waterway development. Verily, the waterway workers have not wrought in vain!

The significant fact lying behind the past and prospective legislation is the power of the people when once aroused—a power not to be confounded for a moment with that of tumult or mob, but inhering in the very spirit and lodging in the innate structure of democracy. True, this power is too often ignored by those for the moment responsible for the public welfare, too little felt by its own possessors; it is seldom stirred save by war or rumors of war, rarely tempted to exercise save by partisan calls at times of political stress; yet although a virtually neglected factor of our national life, it is worthy of weighty consideration.

III

The first, second and third articles of the constitution, respectively, define the legislative, the executive (including the administrative) and the judicative functions of the government. The specifications of the executive function are general to the point of vagueness—naturally enough, in view of the then current antipathy to concentrated authority. Few matters were so faithfully discussed during the constitutiontl convention as the powers of the president;[4] and few of the discussions better exemplify the superlative caution which constantly led the delegates away from definite specifications and toward bare generalities in compromising mooted points. So, just as the instrument is silent on the primary governmental function save in the preamble, the commonplace functions of administration are implied rather than explicitly stated in the second article—being most clearly (or most nearly) defined in the oath or affirmation by the president-apparent that he will "faithfully execute the office of president," which "office" manifestly covers minor governmental affairs not otherwise specified. The indefiniteness was not due to inattention or indifference concerning the administrative function, as the debates clearly show. Mid-course of the deliberation, "Mr. Gouverneur Morris" thus expressed what seems to have been a prevailing view:

> One great object of the executive is to controul the Legislature. The legislature will continually seek to aggrandize & perpetuate themselves; & will seize those critical moments produced by war, invasion or convulsion for

[4] The index to the discussion occupies a page in the recent edition of "Madison's Journal" (edited by Gaillard Hunt; Putnam's, New York and London, 1908).

that purpose. It is necessary then that the Executive Magistrate should be the guardian of the people, even of the lower classes, ag^st. Legislative tyranny, against the great & the wealthy who in the course of things will necessarily compose the legislative body. Wealth tends to corrupt the mind to nourish its love of power, and to stimulate it to oppression. History proves this to be the spirit of the opulent. The check provided in the 2^d branch was not meant as a check on legislative usurpations of power, but on the abuse of lawful powers, on the propensity in the 1st branch to legislate too much to run into projects of paper money & similar expedients. It is no check on legislative tyranny. On the contrary it may favor it, and if the 1st branch can be seduced may find the means of success. The executive therefore ought to be so constituted as to be the great protector of the mass of the people. It is the duty of the executive to appoint the officers & to command the forces of the republic: to appoint 1. ministerial officers for the administration of public affairs. 2. officers for the dispensation of Justice. Who will be the best judges whether these appointments will be well made? The people at large, who will know, will see, will feel the effects of them. Again who can judge so well of the discharge of military duties for the protection & security of the people, as the people themselves who are to be protected & secured?[5]

Unhappily, the indefiniteness begat uncertainty, which has multiplied with the growth of the country; for public affairs requiring administrative attention tend to increase geometrically (just as do transportation lines) with the number of individuals and communities touched. Under the natural desire to protect prerogatives (so clearly foreseen by Morris), and with a facility due to the weight of numbers, the congress gradually grew inattentive to the first duty of the president under the constitution ("He shall, from time to time, give to the congress information of the state of the union, and recommend to their consideration such measures as he shall judge necessary and expedient"), and drifted into the habit of obtaining "information of the state of the union" by more cumbrous methods directly through their own committees or indirectly (and of course unconstitutionally) from the administrative departments. Moreover, they increasingly ignored the warning of George Washington (the presiding officer and moving spirit in the constitutional convention) in that ever-memorable farewell address read annually in their hearing: "Let me . . . warn you in the most solemn manner against the baneful effects of the spirit of party generally. . . . The alternate domination of one faction over another, sharpened by the spirit of revenge natural to party dissention . . . serves always to distract the public councils and enfeeble the public administration"—so that the nominally representative congress has virtually ceased to act in behalf of the people and come to act instead in behoof of party, in ways for which no shadow of constitutional warrant exists. It would appear that the gravest apprehensions of Washington and Morris have been realized in a policy of special legislation so pronounced that—mirabile dictu!—fully 99 per cent. of the bills

[5] *Ibid.*, Vol. II., pp. 1–2.

introduced during an ordinary session are special, local or personal in whole or in part, while far the larger part of the committee work and public debate appears to be devoted to special or local interests! Naturally little time and thought are left for general laws, touching alike the entire citizenry; and naturally the custom of special legislation under party control opens easy way for such machine organization that a half-dozen shrewd manipulators may assume leadership in either house and completely dominate legislation. So far has this tendency run that it is to-day a grave question—the gravest in our history—whether our current laws are framed in the interests of our ninety millions or in the interests of special privilege reducible in the last analysis to a scant dozen "captains of industry": and hence whether after all representative government is inherently and permanently stable. The "propensity" of the congress "to legislate too much" has indeed been checked from time to time in the manner forecast by Morris; for while some administrations acquiesce, others hold out for a stricter conformity with the constitution. George Washington sought to carry out the intent of the instrument framed under his chairmanship, and was so savagely assailed for "usurpation" that he declared death preferable to public service; Abraham Lincoln carried forward the administrative affairs of his terms through sheer force of personality, aided indirectly by the military activity of the time; no less competent authority than the present president of the United States once signalized Grover Cleveland's insistence that the presidency carries power coequal with those of the congress as *the* notable feature of his administrations; and Theodore Roosevelt's policy was consistently parallel and still more vigorous, even to his final and most trenchant presidential message pointing out the unconstitutionality of an item in the sundry civil act passed as his term closed. Meantime some heads of executive departments shrank from assuming administrative responsibilities; yet under growing necessity they have gradually become our chief administrative officers.

Verily the price of indefiniteness as to the administrative function in our fundamental law has been large! Not only have confusion and friction arisen, with enormous attendant expense, but the relatively simple duties of administration are ill-performed. The advocates of waterway improvement were among the first to notice that nearly all our waterway enactments to date are special, and tend to magnify rather than merge sectional and political interests; and that the flood of special bills and local items has so far diverted effort from general legislation that even unto this day the country lacks fundamental laws relating to waters, and is weakly perpetuating monarchial common-law doctrines not only unsuited to current conditions but such as the constitution was designed to annul or forestall! The waterway workers are no longer slow to condemn methods which have permitted—if indeed they have

not caused—the decline and disappearance of navigation from the finest river system of the world in a country suffering from the lack of transportation facilities. Already a majority of the states are moving, and many citizens in every state are astir; and the prevailing sentiment runs along the lines forecast century-before-last by Gouverneur Morris and George Washington.

IV

When popular assemblies "demand and direct" action relating to waterways, regardless of party and under a suffrage penalty, the awakening means more than mere recognition of bad legislative and administrative methods; it extends to that innate and primary power seized on by the founders as a substitute for the "divine right of kings"—*i. e.,* the power of the people defined in the preamble of the constitution and exercised through the suffrage. While this power has existed throughout our history, the act of suffrage is the last to be realized as essentially governmental—indeed as the supreme function of democratic government. The spirit of free citizenship arises slowly; to the anthropologist it is the latest self-conscious attribute acquired by mankind in that long course of human progress stretching from the prime to the present. Even in our Atlantic tidewater states, the real home of democracy, few citizens feel the franchise as in and of itself a function of government; in oratorical flights they hear and even declare that ours is a government of the people by the people for the people, yet only the exceptional citizen actually *senses* the casting of his ballot as a function no less governmental in character than those delegated thereby to his fellow-citizens acting as president and representative and judge. Now this is the sense stirred by the non-partisan waterway and other conventions, particularly in the newer states west of the Appalachians; it is the sense stirred as well in DesMoines and other municipalities governed by the commission system carrying provision for initiative and referendum and recall—the sense of innate *power* exercised through the elective function.

Concurrently with the sense of power the realization of rights is arising; and naturally enough, first as to the waters. Finding nation and most states apathetic, the more progressive waterway advocates looked into fundamental questions for themselves; and now, as a member of the supreme bench recently declared half querulously, "The country is full of constitutional lawyers." Five years ago, few citizens cared to consider the ownership of water in itself; to-day tens of thousands are familiar with the tenth amendment ("The powers not delegated to the United States by the constitution, nor prohibited by it to the states, are reserved to the States respectively or to the people"), and hold that since this resource was never granted to the nation or conveyed to the states it necessarily belongs to the people as a heritage no less inde-

feasible than the common title to sunlight and air, or indeed the equal rights to life, liberty and the pursuit of happiness; and three great conventions during last year adopted in substance the water plank made public by the senate committee on the conservation of natural resources.

We adhere to the principle arising in our constitution and incorporated in statutes recently enacted in several states that the waters belong to the people, and maintain that this right of the people is inherent and indefeasible; and while recognizing the necessity of administering this invaluable possession of the people by state and federal agencies, each within its appropriate jurisdiction, we deny the right of municipalities or of state and federal governments to alienate or convey water by perpetual franchises or without just consideration in the interests of the people.

With the sense of power and the realization of rights, the consciousness of duty is spreading. Until recently, provision for waterway improvement or other public works otherwise than by direct appropriation was commonly deemed chimerical; and citizens were led by advice of their representatives and the policy of congress to look on local appropriations as spoils of conquest rather than general contributions to the public good—whereby the "pork-barrel" was kept open and the appropriations went for "works" with little regard for actual navigation of the waters. Now, seeing that despite the expenditure of hundreds of millions on waterway "works" navigation of the rivers has declined, the people demand business-like methods whereby public funds shall be expended only for commensurate public benefits; and since the people have spoken, presidents, governors and probably a majority of the congress are concurring in the wisdom of issuing bonds to cover the cost of continuously and increasingly beneficial public improvements. Almost never before has the issue of bonds been contemplated without more or less open guarantee from Wall Street; but now legion citizens clamor for opportunity to share public burdens directly on a patriotic basis rather than indirectly through the expensive medium of special interests—for in the end the people pay. Under this pressure bills have already been introduced in the congress providing for waterway improvement on the basis of bonds issued in small denominations bearing interest too low to tempt bankers and brokers; and the adoption of this popular policy promises to mark America's most definite step toward making her citizens joint owners rather than passive tenants of their common country, and thereby at once raising patriotism to a higher plane and insuring stability of the nation.

The recognition of rights and duties respecting the waters leads to juster appreciation of other resources, which were of no account when the constitution was framed but have acquired value through the natural growth and orderly development of our population and industries; and to-day several of our forty-odd state conservation commissions hold that in legislative or other action looking toward wiser use and conservation

of the natural resources the people are but protecting their own. The growth of the sense of common welfare has been greatly impeded by court decisions based on common-law doctrines which the constitution was designed to displace, decisions sometimes tincturing later legislation; yet several courts have fairly kept pace with the growing sense of eternal equities among the people—they who adopted the constitution partly to provide a judicative mechanism adapted to their own needs and subject to their own supreme will: The decision of the supreme court of Maine that the public are entitled to a voice in the management of forests affecting stream-flow; the finding of the New Jersey court of errors and appeals, sustained by the supreme court of the United States, that the people have a residuary right in the waters; the opinion of the supreme court in the Rio Grande case that the government may maintain navigability by protecting the source waters—these and other decisions tending toward closer unity of interest among all the people are signs of the times. So, too, are the enactments by the congress for reclaiming lands and constructing canals under the "general welfare" clause of the constitution, and providing for the Panama Canal and for operations in the insular possessions under the same constitutional warrant—enactments viewed askance by ultra-strict constructionists, yet amply sustained by that court of final appeal, the judgment of the people expressed through their franchise and sustained by their own paramount power.

V

The waterway and conservation movements are still young, and may reasonably be expected to contribute continuously to that public welfare by which they were inspired. Whatever they may do in the future, they have already done much. They have revealed to the people a growing sense of their own powers and rights and duties as citizens. They have brought to light and started toward rectification our ineffective if not actually repressive methods of administration by legislative machinery. They have shown the inherent rights of the people in and to those material resources given value by their own work, and on which their own prosperity and perpetuity depend; and thereby they have warmed the spirit of unity among citizens and states. They have stirred patriotism more than any peaceful issue before, deeply as only bloody wars have done in the past. Incidentally, they are surely establishing the elective function as the primary power of representative government, and will no less surely establish the administrative function as correlative with those of legislative and judicative character.

ASSOCIATE MEMBERS OF AMERICAN SOCIETIES

By Professor EDWARD C. PICKERING

HARVARD COLLEGE OBSERVATORY

TWO papers on "Foreign Associates of National Societies" were published in The Popular Science Monthly, Vol. 73, p. 372, and Vol. 74, p. 80, in which the foreign membership of the seven great scientific societies of the world was discussed. It is the object of the present paper to make a similar study of the associate and honorary membership of the leading American societies, based on the latest printed lists. To avoid confusion, members paying fees will be called residents, those who live at a distance and pay no fees, associates, and foreigners, honorary members. All of the American members of the National Academy and the honorary members of the New York Academy, if Americans, will be included in the second class.

The oldest of American scientific societies is the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge. It was founded in 1743, on the initiative of Franklin. Its membership consists of 165 residents, who live within thirty miles of Philadelphia, 224 associates and 113 honorary members. The number of persons elected each year is limited to fifteen Americans and five foreigners.

The American Academy of Arts and Sciences, founded in 1780, with its headquarters in Boston, is the second oldest scientific society. The numbers of residents (citizens of Massachusetts), associates and honorary members are 193, 87 and 63, and are limited to 200, 100 and 75, respectively.

The New York Academy of Sciences was founded in 1817. The numbers of residents, associates and honorary members are 468, 139 and 48, respectively. The numbers of the last two classes are limited to 200 and 50, respectively.

The National Academy of Sciences was founded in 1863, with its headquarters in Washington. Its membership consists of 113 associates and 45 honorary members. The number of the latter class is limited to 50.

Lists were next prepared of the associates and honorary members of these societies. Table I. contains a list of those Americans whose names appear on two or more of these lists. The successive columns give the name, place of birth, college, residence, specialty, date of birth and age at the time of election into each of the four societies. Place of birth and residence are indicated by states, or countries, except in the

TABLE I AMERICAN ASSOCIATES

Name	Birth	College	Residence	Specialty	Bir.	P	B	N	W
Abbe, C.	N. Y. City	A.B. City, N. Y.	Washington	Meteorol.	1838	33	46	...	41
Abbot, H. L.	Mass.	West Point	Cambridge	Engineer.	1831	31	*32*	...	41
Abbott, C. C.	N. J.	M.D. Penn.	Trenton	Zoology	1843	46	...	40	...
Allen, J. A.	Mass.	— Harvard	New York City	Zoology	1838	40	*33*	*36*	38
Ames, J. S.	Vermont	A.B. J. Hopkins	Baltimore	Physics	1864	41	...	...	45
Angell, J. B.	R. I.	A.B. Brown	Ann Arbor	Educ.	1829	60	39	...	...
Bailey, L. H.	Michigan	B.S. Michigan	Ithaca	Agric.	1858	38	42	...	...
Barnard, E. E.	Tennessee	— Vanderbilt	Williams Bay	Astron.	1857	46	35	...	...
Barus, C.	Cincinnati	— Columbia	Providence	Physics	1856	47	34	...	36
Becker, G. F.	N. Y. City	A.B. Harvard	Washington	Geology	1847	60	...	...	54
Bell, A. G.	Scotland	— London	Washington	Physics	1847	35	*30*	31	36
Billings, J. S.	Indiana	A.B. Miami	New York City	Physiol.	1838	49	43	...	45
Boas, F.	Germany	— Heidelberg	New York City	Anthrop.	1858	45	...	*30*	42
Bowditch, H. P.	Boston	A.B. Harvard	Jamaica Plain	Physiol.	1840	64	*32*	...	47
Branner, J. C.	Tennessee	B.S. Cornell	Stanford	Geology	1850	36	...	34	55
Brush, G. J.	Brooklyn	Ph.B. Yale	New Haven	Mineral.	1831	34	40	45	37
Campbell, D. H.	Michigan	Ph.M. Mich.	Stanford	Botany	1859	51	39	...	...
Campbell, W. W.	Ohio	B.S. Michigan	Mt. Hamilton	Astron.	1862	41	...	...	40
Cattell, J. McK.	Penn.	A.B. Lafayette	Garrison	Psychol.	1860	28	...	*34*	41
Chamberlin, T. C.	Illinois	A.B. Beloit	Chicago	Geology	1843	62	58	55	60
Chandler, C. F.	Mass.	— Harvard	New York City	Chem.	1836	39	...	29	38
Chittenden, R. H.	Connecticut	Ph.B. Yale	New Haven	Physiol.	1856	48	...	...	34
Choate, J. H.	Mass.	A.B. Harvard	New York City	Diplom.	1832	74	68	...	...
Clarke, F. W.	Boston	S.B. Harvard	Washington	Chemis.	1847	57	...	*29*	62
Comstock, C. B.	Mass.	West Point	New York City	Engineer.	1831	...	61	...	53
Coulter, J. M.	China	A.B. Dartmouth	Chicago	Botany	1851	...	41	...	58
Dall, W. H.	Boston	— Harvard	Washington	Zoology	1845	52	...	25	52
Dana, E. S.	Connecticut	A.B. Yale	New Haven	Mineral.	1849	47	44	36	35
Davenport, C. B.	Connecticut	B.S. Brooklyn	Spring Harbor	Zoology	1866	41	40	...	...
Davidson, G.	England	A.M. Mil. H. S.	San Francisco	Geodesy	1825	41	62	...	49
Davis, W. M.	Philadel.	S.B. Harvard	Cambridge	Geog.	1850	49	*34*	48	54
Dutton, C. E.	Connecticut	A.B. Yale	Englewood	Geology	1841	30	...	...	43
Emmons, S. F.	Boston	A.B. Harvard	Washington	Geology	1841	42	62	...	51
Farlow, W. G.	Boston	A.B. Harvard	Cambridge	Botany	1844	61	*30*	...	35
Flexner, S.	Kentucky	M.D. Louisville	New York City	Physiol.	1863	38	...	*43*	45
Frost, E. B.	Vermont	A.B. Dartmouth	Williams Bay	Astron.	1866	43	...	...	42
Furness, H. H.	Philadel.	A.B. Harvard	Wallingford	Author	1833	*47*	64	...	...
Gilbert, G. K.	New York	A.B. Rochester	Washington	Geodesy	1843	59	50	27	40
Gill, T. N.	N. Y. City	A.M. Columbia	Washington	Zoology	1837	30	...	21	36
Gooch, F. A.	Mass.	A.B. Harvard	New Haven	Chem.	1852	55	38	...	45
Goodale, G. L.	Maine	A.B. Amherst	Cambridge	Botany	1839	54	*35*	50	51
Hadley, A. T.	Connecticut	A.B. Yale	New Haven	Econom.	1856	46	46	...	...
Hague, A. D.	Boston	Ph.B. Yale	Washington	Geology	1840	63	64	...	45
Hale, G. E.	Chicago	B.S. Mass. Inst.	Pasadena	Astron.	1868	34	33	30	34
Hastings, C. S.	Clinton	Ph.B. Yale	New Haven	Physics	1849	57	...	...	40
Hilgard, E. W.	Bavaria	— Zurich	Berkeley	Geology	1833	...	71	...	39
Hill, G. W.	N. Y. City	A.B. Rutgers	West Nyack	Astron.	1838	65	*27*	60	36
Hillebrand, W. F.	Honolulu	— Cornell	Washington	Chem.	1853	53	...	...	55
Holden, E. S.	St. Louis	B.S. Washing.	West Point	Astron.	1846	51	39	...	39
Holmes, W. H.	Ohio	B.S. McNealy	Washington	Geology	1846	53	...	54	59
Howell, W. H.	Baltimore	A.B. J. Hopkins	Baltimore	Physiol.	1860	43	...	...	45
Jordan, D. S.	New York	M.S. Cornell	Stanford	Zoology	1851	54	...	25	...
Koenig, G. A.	Germany	M.E. Pol. Carl.	Houghton	Chem.	1844	30	...	32	...
Libbey, W.	N. Y. City	Princeton	Princeton	Geology	1855	42	...	39	...
Mahan, A. T.	New York	Naval Academy	New York City	History	1840	57	63	...	...
Mall, F. P.	Iowa	M.D. Michigan	Baltimore	Physiol.	1862	44	39	...	45
Mallett, J. W.	Ireland	Ph.D. Gott.	Charlottesville	Chem.	1832	53	51	44	...
Mark, E. L.	New York	A.B. Michigan	Cambridge	Zoology	1847	60	...	...	56
Mendenhall, T. C.	Ohio	———	Worcester	Physics	1841	58	*43*	...	46
Merriam, C. H.	N. Y. City	— Yale	Washington	Zoology	1855	47	...	19	47
Merriman, M.	Connecticut	Ph.B. Yale	New York City	Engineer.	1848	...	...	50	...
Michelson, A. A.	Germany	Naval Academy	Chicago	Physics	1852	50	33	...	36
Minot, C. S.	Boston	B.S. Mass. Inst.	Boston	Zoology	1852	44	*30*	26	45
Mitchell, S. W.	Philadel.	— Pennsylvania	Philadelphia	Physiol.	1829	*33*	36	...	36

Name	Birth	College	Residence	Specialty	Bir.	P	B	N	W
Moore, E. H.	Ohio	A.B. Yale	Chicago	Math.	1862	43	39	...	9
Morley, E. W.	New Jersey	A.B. Williams	Hartford	Chem.	1838	65	54	...	59
Morse, E. S.	Maine	— Harvard	Salem	Zoology	1838	57	*31*	26	38
Morse, H. N.	Vermont	A.B. Amherst	Baltimore	Chem.	1848	55	...	...	59
Monroe, C. E.	Mass.	S.B. Harvard	Washington	Chem.	1849	42	*42*	...	...
Nef, J. N.	Switzerland	A.B. Harvard	Chicago	Chem.	1862	...	46	...	42
Nichols, E. L.	England	B.S. Cornell	Ithaca	Physics	1854	50	47	...	47
Nichols, E. F.	Kansas	B.S. Kansas	Hanover	Physics	1869	37	...	...	39
Osborn, H. F.	Connecticut	A.B. Princeton	New York City	Zoology	1857	30	44	*34*	43
Peckham, S. F.	R. I.	— Brown	Brooklyn	Chem.	1839	58	...	37	...
Peirce, B. O.	Mass.	A.B. Harvard	Cambridge	Physics	1854	56	*30*	...	52
Peirce, C. S.	Mass.	A.B. Harvard	Milford	Logic	1839	...	*28*	...	37
Pickering, E. C.	Boston	S.B. Harvard	Cambridge	Astron.	1846	50	*21*	30	27
Prudden, T. M.	Connecticut	A.B. Yale	New York City	Physiol.	1849	...	55	*41*	52
Pumpelly, R.	New York	A.B. Yale	Newport	Geology	1837	37	*33*	31	35
Pupin, M. I.	Hungary	A.B. Columbia	Yonkers	Physics	1858	38	47	*32*	47
Putnam, F. W.	Mass.	S.B. Harvard	Cambridge	Anthrop.	1839	56	*26*	...	46
Remsen, I.	N. Y. City	A.B. City, N. Y.	Baltimore	Chem.	1846	33	*29*	30	36
Richards, T. W.	Philadel.	S.B. Harvard	Cambridge	Chem.	1868	34	*23*	...	31
Royce, J.	California	A.B. California	Cambridge	Philos.	1855	53	*36*	...	51
Sargent, C. S.	Boston	A.B. Harvard	Jamaica Plain	Botany	1841	41	*37*	...	54
Scott, W. B.	Cincinnati	A.B. Princeton	Princeton	Paleon.	1858	28	...	40	48
Scudder, S. H.	Boston	A.B. Williams	Cambridge	Zoology	1837	41	*31*	39	40
Sherwood, A.	Penn.	— Chicago	Portland, O.	Geology	1848	27	...	28	...
Smyth, C. H.	New York	Ph B. Columbia	Princeton	Geology	1866	42	...	29	...
Stephens, H. M.	Missouri	A.B Dickinson	Berkeley	Zoology	1868	29	32	...	...
Stevens, W. L.	Georgia	A.B. S. Carol.	Lexington, Va.	Physics	1847	37	...	43	...
Thomson, E.	England	A.B. Phil. C. S.	Swampscott	Engineer	1853	*23*	*35*	...	54
Trelease, W.	New York	B.S. Cornell	St. Louis, Mo.	Botany	1857	46	35	...	45
Trowbridge, J.	Boston	S.B. Harvard	Cambridge	Physics	1843	53	*28*	34	35
Van Hise, C. R.	Wisconsin	B.M.E. Wis.	Madison	Geology	1857	52	...	43	45
Verill, A. E.	Maine	S.B. Harvard	New Haven	Zoology	1839	...	48	28	33
Walcott, C. D.	New York	———	Washington	Geology	1850	47	49	48	46
Webster, A. G.	Mass.	A.B. Harvard	Worcester	Physics	1863	43	*32*	...	40
Welch, W. H.	Connecticut	A.B. Yale	Baltimore	Physiol.	1850	46	51	...	45
White, A. D.	New York	A.B. Yale	Ithaca	Educat'n	1832	37	36	...	...
White, I. C.	West Va.	A.M. W. Virg.	Morgantown	Geology	1848	30	...	26	...
Whitman, C. O.	Maine	B.A. Bowdoin	Chicago	Zoology	1842	57	*48*	58	53
Wood, H. C.	Philadel.	M.D. Penn.	Philadelphia	Physiol.	1841	...	46	25	38
Woodward, R. S.	Michigan	C.E. Mich.	Washington	Astron.	1849	53	47	...	47
Wright, A. W.	Connecticut	A.B. Yale	New Haven	Physics	1836	60	...	40	45

case of a few large cities. The four societies are indicated by the initials of the headquarters of each, P, B, N and W. Resident membership is indicated by italics.

The discussion of Table I. is complicated by the fact that several men were elected as residents, and later moving to another state, were made associates. Three men were made honorary members of the New York Academy. In all these cases, the first election is that entered in the table. Twenty-one men, including the three just mentioned, are members of all four societies, and will be designated below as of class A.

From the second column, it appears that the birthplaces are distributed as follows: Massachusetts, 22; New York, 18; Connecticut, 10; Pennsylvania, 7; Maine and Ohio, 4 each; Michigan and Vermont, 3 each; foreigners, 13, of whom 5 came from Great Britain, and 4 from Germany. The only cities furnishing more than one member are

Boston, 11; New York, 8; Philadelphia, 5; Cincinnati, 2. Of 105, 41 come from New England and 26 from the Middle States, making nearly two thirds, in all. Of class A, 6 were born in New York, including 3 in New York City; 5 in Massachusetts, 4 of them in Boston; 3 in Maine, and 2 in Connecticut.

A grouping of the colleges where these men got their education led to unexpected results, as follows: Harvard College, 12; Lawrence Scientific School, 12; Yale College, 9; Sheffield Scientific School, 6; Cornell, Michigan and common schools, 5 each; Columbia and Princeton, 3 each. Nine colleges educated 2 each. Harvard and Yale, therefore, educated 39, or rather more than a third of the whole. The numbers of living graduates in the four institutions, Harvard College, Lawrence Scientific School, Yale College and Sheffield Scientific School, are about 12,000, 1,200, 8,000 and 4,000. Accordingly, the proportion is 1 out of 1,000, 100, 900 and 700, for the four institutions, respectively. The average numbers of societies are 2.5, 3.3, 2.6 and 2.5, respectively. Evidently the greatest possible number is 4.0, and the least, 2.0. The number of graduates of the other institutions is too small to determine averages with accuracy. The average 3.3 for the Lawrence Scientific School is only surpassed by the Massachusetts Institute of Technology, 2 members, average 4.0, and Williams College, 2 members, average, 3.5. Of class A, 5 are graduates of the Lawrence School, 2 of Yale College and 2 as just stated of the Massachusetts Institute of Technology.

The present residence of these men according to cities is as follows: Boston, New York and Washington, 15 each; New Haven, 8; Baltimore and Chicago, 6 each; Princeton, 4; Berkeley, Ithaca and Stanford, 3 each; Philadelphia, Williams Bay and Worcester, 2 each. The suburbs of each city are included in it. Thus, Boston includes Cambridge, and represents, practically, Harvard College. Of class A, 6 are residents of Boston, 3 of New York, 3 of Washington, 2 of Chicago and 2 of New Haven. While birthplaces indicate conditions of about sixty years ago, and colleges forty years ago, residences indicate nearly present conditions.

The other columns of Table I. are better discussed in connection with the corresponding columns of Table II. The latter gives a list of the foreigners who are honorary members of two or more of these societies. The successive columns give the name, residence, specialty, year of birth, age at time of election into each of the four societies and number of the seven national societies of which each man is a member. The numbers in the last column are taken from the article already mentioned.

In Table II. the residences are distributed as follows: Germany, 16, of which 8 are in Berlin and 3 in Leipzig; England, 15, of which 7 are in London and 4 in Cambridge; France, 4, all in Paris; Holland,

3; Austria, 2, both in Vienna; Edinburgh, Palermo, Berne and Stockholm, 1 each. Eight men are members of all four societies, and of them five are residents of England.

TABLE II

HONORARY MEMBERS

Name	Residence	Specialty	Birth	P	B	N	W	No.
Auwers, A.	Berlin	Astronomy	1838	...	42	60	45	7
Baeyer, A. von	Munich	Chemistry	1835	75	49	...	63	7
Bornet, E.	Paris	Botany	1828	...	65	...	73	3
Broegger, W. C.	Christiania	Mineralogy	1851	48	...	53	52	4
Bryce, J.	Washington	Diplomacy	1838	57	55	...	...	...
Darwin, G. H.	Cambridge	Geography	1845	...	53	54	59	4
Delitsch, F.	Berlin	Archæology	1850	54	52	...	...	...
DeVries, H.	Amsterdam	Agriculture	1848	55	...	56	56	3
Dewar, J.	Cambridge	Physics	1842	57	...	60	65	...
Diels, H.	Berlin	Philology	1848	61	59	...	...	...
Engler, A.	Berlin	Botany	1844	62	57	...	...	...
Fischer, E.	Berlin	Chemistry	1852	57	56	49	52	7
Geikie, A.	Surrey	Mineralogy	1835	45	65	41	66	6
Geikie, J.	Edinburgh	Geology	1839	37	...	62	...	...
Gill, D.	London	Astronomy	1843	67	67	...	55	6
Haeckel, E.	Jena	Zoology	1834	51	...	60	...	2
Hann, J.	Vienna	Meteorology	1839	...	63	60	...	3
Hoff, J. H. van't	Berlin	Chemistry	1852	52	43	...	44	7
Hooker, J. D.	Sunningdale	Botany	1817	52	49	62	66	6
Kapteyn, J. C.	Groningen	Astronomy	1851	56	...	...	56	...
Klein, F.	Göttingen	Geometry	1849	...	55	47	49	6
Kohlrausch, F.	Marburg	Physics	1840	69	60	...	...	5
Kronecker, H.	Berne	Medicine	1839	...	62	...	62	2
Lankester, E. R.	London	Zoology	1847	56	55	51	56	5
Larmor, J.	Cambridge	Physics	1857	...	46	...	51	...
Lister, J.	London	Medicine	1827	70	66	...	71	4
Lockyer, J. N.	Kensington	Astronomy	1836	38	...	44	...	3
Lorentz, H. A.	Leyden	Physics	1853	53	...	...	53	5
Maspero, G. C. C.	Paris	Philology	1846	45	39	...	...	...
Nansen, F.	Lysaker	Geography	1861	36	...	37	...	3
Ostwald, W.	Leipzig	Chemistry	1853	...	52	55	53	4
Penck, A. F. K.	Berlin	Geography	1858	50	...	40	51	...
Pfeffer, W. F.	Leipzig	Botany	1845	64	52	53	58	6
Picard, E.	Paris	Geometry	1856	54	47	47	47	5
Poincaré, H.	Paris	Geometry	1854	45	47	46	44	7
Ramsay, W.	London	Chemistry	1852	47	...	49	52	7
Rayleigh, J. W.	Essex	Physics	1842	44	46	57	56	7
Retzius, N. G.	Stockholm	Zoology	1842	...	65	...	57	6
Roscoe, H. E.	Leatherhead	Chemistry	1833	70	57	54	...	3
Stoney, G. J.	London	Physics	1826	76	...	78	...	...
Strasburger, E.	Bonn	Botany	1844	...	48	64	54	5
Suess, E.	Vienna	Mineralogy	1831	55	...	...	67	7
Thomson, J. J.	Cambridge	Physics	1856	47	46	40	47	3
Unwin, W. C.	London	Engineering	1838	52	62	...	...	...
Waldeyer, W.	Berlin	Mineralogy	1836	68	...	...	73	...
Wundt, W.	Leipzig	Physiology	1832	63	...	72	77	...

Considering now the 105 Americans in Table I., and the 46 foreigners in Table II., we find that the four societies, as already stated, contain 224, 87, 142 and 113 associates, and 113, 63, 48 and 45 honorary members. The numbers of these included in Table I. are 96, 70, 48 and 82, and in Table II., 36, 31, 27 and 32.

Sciences are not easily grouped, since many are closely connected. An approximate grouping of Table I. gives: geology, 20; zoology, 15; astronomy, 15; physics, 14; chemistry, 13; physiology, 10; botany, 7; miscellaneous, 11. Class A gives: geology, 7; zoology, 6; astronomy, 3; physics, 3; chemistry, 1; botany, 1. Table II. gives: astronomy, 9; physics, 7; chemistry, 7; geology, 6; botany, 5; zoology, 3; physiology, 3; miscellaneous, 6. The large number of geologists and zoologists in Table I., and especially in class A, is remarkable, and the reversion of this condition in Table II. Of the 20 geologists in Table I. there is only 1 mineralogist, while in Table II., of 6 geologists, there are 4 mineralogists. Table I. contains but 1 mathematician, while Table II. contains 4.

Important conclusions may be drawn from the order of election, but the discussion is beset with unusual difficulties. A society which chose members who were later elected into all the other societies would display remarkable skill. In class A, the number of members first elected by the four societies is 2, 10, 8 and 1, respectively. But it is much easier to become a resident than an associate, and 13 members were elected as residents of the American Academy, and 2 of the New York Academy. Omitting these, the numbers become 3, 0, 13 and 5. Accordingly, the New York Academy appears to have shown extraordinary skill in selecting early, men of such ability that later they were chosen by all the other societies. This result is confirmed by the eight foreigners who are members of all four societies. Four of these were first elected by the New York Academy, in two cases before they were elected by either of the seven leading European societies. The last column of Table II. shows that 32 men are members both of the European and American societies; of these, 23 were first elected by a European society, 6 by an American Society and 3 in the same year by both. Of the 9 in the last two classes, 6 were chosen first by the American Academy.

The numbers elected in the different societies, during the last ten years, differ greatly. Thus, for associates, we have from 1901 to 1905, 26, 15, 0 and 20, and for 1906 to 1910, 17, 1, 1 and 13. For honorary members no such differences occur, the numbers for 1901 to 1905 being 8, 11, 9 and 12, and for 1906 to 1910, 11, 5, 3 and 9. Only 2 honorary members were elected into the National Academy before 1896, both in 1883. In the New York Academy, 11 associates were elected in 1876. Of course all of these numbers relate only to the selected lists contained in Tables I. and II.

THE PALEONTOLOGIC RECORD

ONTOGENY: A STUDY OF THE VALUE OF YOUNG FEATURES IN DETERMINING PHYLOGENY

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IN this paper I want to study what value is to be given to the principle that ontogeny is a brief recapitulation of phylogeny, when it comes to the concrete determination of the ancestry of a given genus. For the purpose three types have been studied carefully and several more for confirmations, the principal study being between the young and adult of the pig, cat and man, the differences being noted to see if they suggested the forms considered ancestral.

First let us consider the skull of a six weeks' pig in comparison with that of the adult, the two having been drawn to the same length. The first and most marked variation is in the brain case, that of the young being relatively vastly larger. The same is especially true of the sense capsules of the ear and eye. The later growth is much greater in those parts of the skull designated as facial, or having to do with the jaws and their supports. Then there is a change in the axis of the skull, this being due to the growth of the maxilla region, and lastly where there is any cellular bone or bone spaces they are developed in later life. This factor is especially well shown in the development of the elephant skull and in ruminants. It is coincident with high crests and marked protuberances.

While most of the features have been indicated in the pig, the same comparison in the cat reveals the same excessive development of the brain case and sense organs, the same weakness of the jaws and change in the axial relations, and this may be further confirmed in looking at the contrast between a three-year-old child's skull and that of an adult.

The conclusions then to be drawn from this hasty comparison of the two skulls are, first, that the shape of the skull in the young shows the excessive development of the brain and sense capsules, so that the appearance is not that of a primitive animal, but exactly the contrary, the appearance which the genus would assume were its mental or nervous development carried to a much higher degree than is the case. The embryonic development of the brain and sense organs is pushed far toward the beginning, and is matured, as far as size is concerned, the earliest of any of the systems. The skull is first an envelope for the brain and sense organs and is therefore profoundly modified by this embryonic peculiarity, and *the younger the individual the less like the adult or ancestor the skull is shaped.*

Secondly, the change of axis is not in the ancestral direction, the excessive weak condition of the jaws being again an embryonic adaptation and not an ancestral one.

Lastly, in the development of cancellous tissue is a condition which more nearly approximates the phylogenetic development, but here even the use of young features is deceptive, for it is seldom that this cellular bone is developed in the immediate ancestor but is rather found in several genera back, being usually an accompaniment of the development of the heavy facial portion of the skull. So much for form.

Turning to the dentition. The milk set of the pig and those of the adult are drawn side by side, and it is seen that while the front teeth of the young approximate those of the adult, the comparison is between the complicated premolar and molar sets. Briefly, of the four premolars, if all present, in the young (and often but three are developed) the two in front resemble the premolars to succeed them in the permanent set, while the two rear milk premolars resemble the permanent molars, the last milk premolar being especially like the last molar. This granted, the interest centers around whether the pattern of the milk teeth is such as to indicate the ancestry. A glance at the pig and its young will show that while the detail is not exactly the same in young and old, yet they are so alike that no one would identify a single milk molar as *Hyotherium* or any other suine genus, but would have to put it in the genus *Sus*. Taking other cases among the Ungulata, the history of the naming of the Miocene genera of horses gives a good example. There are, according to Gidley, four genera, *Hyohippus, Parahippus, Merychippus* and *Protohippus;* of these, three were founded on young teeth, *i. e.,* the first three named. When it was recognized that they were young teeth, they were by Cope assigned to *Protohippus,* but when the adult teeth were found it was clear that the distinctive features of these young teeth were the distinctive features of the adult. For the genus *Merychippus* there is a difference in that the young teeth are not cemented, while the adult are. That is ancestral. In analyzing the descriptions of several genera of horses usually some feature can be found in the milk tooth which is ancestral.

In the Carnivora there is the carnassial tooth which is specialized; in the upper jaw it is the third milk premolar and the fourth in the adult; in the lower jaw it is the fourth milk premolar, and the first molar of the adult. Thus it is clear that it is a different dental follicle which forms the young and the adult carnassial. In the case of the dog the permanent and milk carnassials are approximately alike, but in the case of the cat the inner lobe or protocone occupies a very different place in the young from that of the adult, a position characteristic of none of the Felidæ and suggests some of the apparently unrelated Creodonts.

In the matter of the succession of teeth the follicles which form the last two—the milk premolars—form teeth in the first set of a totally different and usually more advanced character than the teeth to be formed from the same follicles in the permanent set. As a general thing then the conclusion would be that the milk teeth tend to have the same characters as mark the permanent set, but when they vary they often retain characters of the phylogenetically ancestral form. Weber adds that the later the succession the less the difference between the milk and permanent sets.

Turning to the limbs, there are again several distinctly ontogenetic characters, which are by no means ancestral. First, the formation of epiphyses, so that a bone ossifies from three or more centers. This is purely an ontogenetic adaptation and has no phylogenetic significance. Then the articular ends of all the limb bones are greatly enlarged as compared with adults. This again is not phylogenetic but an adaptation, the joints and their ligaments being early approximated to their permanent conditions. Then the length of limbs seems to be effected as an embryonic adaptation. First take the case of man born with disproportionately short arms and legs. The legs have been interpreted as representing a phylogenetic condition, but the same rule does not apply to the arms which were ancestrally long. This feature of short limbs is also characteristic of carnivora and I feel that it is an embryonic adaptation; certainly the ancestral limb can not be deduced from the young condition. Quite the reverse of conditions obtains among the Ungulata where the young at birth have disproportionately long limbs, which with equal certainty does not represent any ancestral condition recapitulated, for the ancestral limb in ancestral forms is shorter. Again, I believe the anomalous legs are adaptations to either the necessity for speed on the part of the young, or for height to reach the teats, suckling being while the parent is standing.

In the cases of the reduction of digits, greater portions of the reduced digits are usually found in the young animals than in the adults, but in the case of the entire loss of a digit it is also lacking in the young and embryo.

The general conclusion of the whole matter would then be that the young give us very little which is not deceptive in reconstructing ancestral forms. In certain cases, namely in the teeth and in reduction of digits, confirmatory points may be obtained, but these must be used with care, the valuable constructive evidence being rather found in adult skeletons, and in morphological comparisons. While allowing that many stages are recapitulated in the development of an individual, the vast number of adaptations impressed on the young to be used after birth, *make their skeletons specialized even from birth,* and *such differences as exist are seldom reminiscent.*

PALEONTOLOGY AND ONTOGENY

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ONTOGENY, or the life history of the individual, is commonly interpreted by zoologists as its embryology, the later stages of development, from infancy to old age, being deemed of little or no importance. This was the case fifty years ago; this is largely the case to-day. From the days when Agassiz first called the attention of zoologists to their one-sided attack of the problem of ontogeny, and urged them to pay attention to the important post-embryonic stages, down to our own time, students of recent animals have for the most part been content to follow the beaten path. They have left to the paleozoologist the study of the later stages in the life history of the individual, and the latter's endeavors in this direction have developed the science of zoontogeny as to-day understood. There was, perhaps, a natural cause for this separation, in the fact that the student of soft tissues finds few changes which he deems worthy of attention, between the embryo and the adult; whereas the student of hard structures generally sees an abundance of such changes. This is especially true of invertebrates, more particularly of such as build external hard structures in which successive additions are marked by the lines of growth. Vertebrates, and invertebrates without permanent hard parts, such as the crustacea, require series of individuals showing the successive steps in development. But mollusks, brachiopods and corals show, by their incremental lines, the steps in the life history during the post-embryonic period, so that one perfect individual suffices to present these later stages in development.

It is not infrequently urged that the hard parts of invertebrates, especially the shells of mollusks, are not reliable indices of ontogenetic development, since they represent only the integument, which is subject to ready modification under the influence of the environment. Such an argument is based on a total ignorance of the relation of the shell or other hard structure to the soft parts of the animal. The paleontologist is convinced that the hard parts of animals are the best indices of its development, since they record in a permanent form all the minute modifications which are not even recognizable in the soft parts. More than this, I believe that shells, those of mollusks at any rate, furnish us with a record of changes wholly independent of the environment, and referable entirely to an inherited impulse towards progressive modification, along definitely determinable lines. I am well aware that I am not expressing the opinion of all paleontologists in this statement, and that this view, moreover, is strongly opposed by some of our ablest European conchologists. But here again I contend that this difference

of opinion is due to a difference of method. When the student of shells directs his attention chiefly to adult characters, this definitely directed variation, independent of environment, is not recognized by him. But no one can study the details of shell ontogeny, especially in the earlier stages, without quickly realizing that ontogenetic development is orthogenetic, and that the inherited impulse towards determinate modifications is the most powerful controlling factor of the animal's life history.

So far as invertebrates are concerned, the study of post-embryonic development was first seriously undertaken by the immortal Hyatt, in his work on the ammonites. To be sure, others before him—notably d'Orbigny—noticed that a distinct series of changes was recognizable in the shell of ammonites, but no one before Hyatt actually employed this method. He himself once told me that when, in the early sixties, he first realized the importance of this method of study when actually applied to shelled organisms, and its value as a guide in phylogeny, it seemed so marvelously simple that he felt sure that the method and its application must be fully understood by all working naturalists. "But," he added, "I soon found that I practically stood alone, and I have spent my life since in the endeavor to convert them to my point of view."

This misunderstanding, on the part of many zoologists, of the ontogenetic method has given rise to their false attitude towards the doctrine of the recapitulation of ancestral characters. This subject will be adequately treated by some of my successors, but I can not forbear to anticipate them to the extent of pointing out this fact: When the embryologist seeks for proof or disproof of this concept in the enormously condensed record of the stages between the ovum and birth, he is bound to be grievously disappointed; for this record, necessarily modified by eliminations, can only furnish general resemblances of the embryo to earlier types, and can not be said to actually recapitulate the life history of the entire race. When, however, the student of post-embryonic ontogeny compares the youthful stages of an individual with the adult of immediately preceding species of the same genetic series, the fact of recapitulation becomes at once apparent.

The post-embryonic life history of an individual falls readily into stages, of which four major ones have been recognized and named, chiefly by Hyatt. These are: (1) the infant or nepionic stage; (2) the adolescent or neanic stage; (3) the adult or ephebic stage, and (4) the senile or gerontic stage, followed by death. These *onto-stages,* as they may be called, are further divided into substages, designated by the prefixes *ana, meta* and *para,* and they may be observed in the ontogeny of all individuals. Moreover, in closely related members of one genetic group, the duration of these stages and substages is approximately uniform. Change in form, however, may vary greatly, and have

no necessary relation to the onto-stages, even if they coincide with them. We have thus a second group of stages, which we may designate *form stages,* or morphic stages, and there will be required distinct designations in each case. The best method of naming these stages is to refer them to the adult ancestral type which they represent.

Thus, in all species of the gastropod shell *Fusus,* the earliest morphic stages are a close recapitulation of the adult of *Fusus porrectus* of the Eocenic. These stages may therefore be called the *F. porrectus* stage. It may be continued for a considerable period of the early life history, covering several onto-stages, or it may be condensed into a short portion of one stage or substage, in accelerated individuals.

It is of considerable importance that onto-stages and morphic stages should be discriminated, so I will introduce another illustration.

In the Miocenic of the Atlantic coast we have the gastropod genus Fulgur well represented. *Fulgur fusiformis* is normally characterized, in the adult, by the possession of a pronounced flat shoulder, which is separated from the body of the shell by an angulation carrying rounded tubercles. Some of the more specialized individuals lose the angulation and tubercles in the last whorl and become rounded. Thus, while normally the species is tuberculated in the ephebic onto-stages, specialized individuals acquire a new morphic stage through the loss of ornamentation. This morphic stage is prophetic of the normal adult of *Fulgur maximum,* and hence may be called the *F. maximum* stage. *F. maximum* itself has in its nepionic onto-stage the characters of adult *F. fusiformis;* hence it may be designated the *F. fusiformis* stage. Some individuals acquire a new stage, namely, a spinous stage, characteristic of the adult of *F. carica.* In the type designated as *F. tritonis,* the nepionic stage is characterized by a fusiformis morphic stage, the neanic largely by the maximum stage, though some of the later neanic stages may actually acquire the *carica* stage. In less specialized individuals the maximum stage may continue into the early ephebic in more specialized ones it ceases early in the neanic, the *carica* stage taking its place. Finally, *Fulgur carica* is characterized by the elimination of the maximum morphic stage, so that the neanic as well as the ephebic onto-stages are characterized by the spines of the *carica* stage, which may even begin in the late nepionic.

In the foregoing, the different morphic stages are shown to be telescoped with the onto-stages, appearing either earlier and earlier in the ontogeny of successive individuals, through the operation of the law of acceleration or tachygenesis; or later and later, through the operation of the complementary law of retardation or bradygenesis. These laws are, of course, only applicable to an orthogenetic series, but in such a series they are competent to produce, by interaction, all conceivable combinations of characters.

The paleontologist, more than any other naturalist, is concerned with the product of these interactions, and to him, oftener than to others, has come the question, Are these results species? and, if so, what are the criteria for the separation of species? The student of hard structures appreciates the difficulty of drawing sharp lines, and one of his most trying tasks is to satisfy the idiosyncrasies of his colleagues in the making of species, subspecies, varieties, etc. The student of hard parts finds transitional forms the rule, and he dare not grind them to powder under his heel with the remark credited to Stimpson, that "that is the proper way to dispose of those damned transitional forms."

The philosophic paleontologist recognizes more readily than any one else the truth of the dictum that nature knows only individuals, and that species are special creations, called into being by the fiat of the naturalist. He is concerned not so much with the origin of species as with the origin of individuals; and while he makes use of the artificial divisions called species, and sometimes finds his chief joy in multiplying and subdividing them, he still recognizes their non-existence, and turns to individuals. He may, perhaps, prefer to speak of mutations, meaning individuals, nevertheless.

But individuals are complex entities, and the paleontologist can not investigate their genesis before he has thoroughly investigated the origin of the parts composing it. As Professor Osborn has said, the paleozoologist is concerned primarily with the origin of structures. He alone is able to trace their development, for he is present at their birth, he follows their whole history, and will be present also at their extinction, for the paleontologist alone is immortal.

PALEONTOLOGY AND THE RECAPITULATION THEORY

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I

BATHER once said that "If the embryologists had not forestalled them, the paleontologists would have had to invent the theory of recapitulation." This may be considered as a fair sample of the attitude of at least the Hyatt school of paleontologists toward the theory. It is doubtful if any paleontologist could be found who wholly rejects it.

In violent contrast with the more or less complete acceptance of the theory by paleontologists, is the attitude of many embryologists and zoologists. Montgomery and Hurst have perhaps put the case against recapitulation more strongly than any one else. The former says, for example,

> The method is wrong in principle, to compare an adult stage of one organism with an immature stage of another.

And again:

> Therefore we can only conclude that the embryogeny does not furnish any recapitulation of the phylogeny, not even a recapitulation marred at occasional points by secondary changes.

Hurst is even more emphatic. He says:

> The ontogeny is not an epitome of the phylogeny, is not even a modified or "falsified" epitome, is not a record, either perfect or imperfect of past history, is not a recapitulation of evolution.

It would seem as though two statements could scarcely be more flatly contradictory than those of Bather and Hurst, just quoted. Nevertheless, I venture to make the assertion that both parties to the recapitulation controversy are right, for the simple reason that they are not talking about the same thing. Grabau has called attention to this, by implication, in one of his papers on gastropods. He states that the recapitulation theory has been placed in an evil light by the habit of embryologists of comparing *embryonic* stages with the adults of existing representatives of primitive types, and that they have commonly neglected to compare the *epembryonic* stages with the adults of geologically older species. In other words, paleontologists have usually dealt, in their comparisons, with epembryonic stages, and embryologists with embryonic stages.

There arises here a question of definition: does the biogenetic law mean that the *ontogeny* is a recapitulation of the phylogeny, or does it mean that the *embryogeny* is a recapitulation of the phylogeny? If we take the general consensus of opinion, we shall find for the former definition; and if we take the words of Haeckel, whose statement of the law is the one usually quoted, we shall again find for the former definition.

It is certainly true, at any rate, that the epembryonic stages may and do show recapitulation, even when the embryonic stages do not, or when the embryogeny is so obscured by secondary adaptations as to be untrustworthy. There are many reasons why adaptations should occur in intra-uterine or larval life to obscure the ancestral record. These have often been stated and discussed, and I shall pass them with this mere mention. That the record of remote ancestors, contained in the embryogeny, may be lost or obscured, while the record of nearer ancestors, contained in the epembryogeny, is still clear and convincing, is my contention; and I hold that this contention is substantiated by the studies of a host of paleobiologists.

While contrasting the views of biologists and paleobiologists, I do not wish to create the impression that all of the former have turned against the theory of recapitulation. Several recent studies of the development of extant forms seem to afford very satisfactory evidence that the theory is not wholly rejected in the house of its fathers. Of

these I may mention the very interesting papers by Griggs on juvenile kelps, Zeleny on the development and regeneration of serpulids, and Eigenmann on the blind vertebrates of North America.

Griggs especially criticizes the views of such critics of recapitulation as His, who holds that the reason why ontogeny seems to recapitulate phylogeny is because the developing organism must from physiological necessity pass from less to more complex stages, more or less resembling ancestral forms; and the views of Morgan, who holds that only embryonic stages of ancestors are repeated. This is the so-called "Repetition Theory." To both of these critics Griggs objects that they confuse physiology and morphology. "The recapitulation theory," he says, "has nothing to do with physiology; it is purely a matter of morphology."

On the first point, that the developmental stages are merely the physiologically necessary steps in the development of the adult organism, the conclusions of Eigenmann and Zeleny are of especial interest. Eigenmann shows that in the blind fish, *Amblyopsis,* the development of the foundations of the eye is normal, and is phylogenic, while the stages beyond the foundations are direct. Zeleny concludes that the ontogenesis of the opercula of serpulids is phylogenic, and recapitulates ancestral characters; but the regeneratory development of the organ is direct, and may be very different from the ontogenetic development. We may ask, therefore, if development takes a certain course only because that is the physiologically necessary way in which the individual or the organ must develop, why should a condition of perfect blindness, with almost total loss of all the eye structures, be attained only by the round-about method of first developing the foundations of a normal eye? Why, again, if there is any physiologically necessary course of development, should the serpulid be able to regenerate the opercula in a manner entirely different from their ontogenesis?

Hatschek, Hurst, Montgomery and others maintain that, if two individuals differ in the adult, they must also differ in the egg, and consequently must be different at all stages between. From this thesis they draw the conclusion that organisms can not recapitulate adult ancestral characters, because any change in the adult stage of an individual, causing it to be different from its parents, involves a change in the entire ontogeny—"the entire row of cells" from the egg to the adult. That there is some sort of change in the entire row of cells we grant; but that this change necessarily affects the *morphology* of the individual or of its organs, up to the adult stage, we do not grant. We have here again a confusion of morphology and physiology. The cell energies may indeed be changed; but unless a change in the cell energies inevitably necessitates a change in the morphology of all the cells or of all the organs which they compose, the argument of Montgomery proves nothing.

If inheritance were perfect, the individual would take exactly the same course in development as its ancestors. That it does not do this in all cases is a more remarkable fact than that in so many cases it follows the ancestral mode of development so closely. This loss of inheritance is due to a progressive condensation of ontogeny, or as it is commonly called, acceleration. Most embryologists misconceive the law of acceleration, limiting it to the omission of characters or stages. With the classic formulation of the law by Hyatt we are all familiar. According to Hyatt, acceleration involves not only omission, but condensation without omission, through the earlier inheritance of characters acquired in the adult or adolescent stages of life. By the unequal acceleration of characters an overlapping, or telescoping, as Grabau calls it, may be introduced. It follows, therefore, that acceleration may be by *elimination,* by *condensation* without change in the order of appearance of characters, and by condensation with change in the order of appearance, or *telescoping.* As conceived by the paleobiologist, the law of acceleration is an explanation of recapitulation, as well as an explanation of the failure to recapitulate.

Another factor in inheritance is retardation, so named by Cope. By the operation of this law, characters that appear late in the ontogeny may disappear in the descendents, because development terminates before the given characters are reached. In this way the ontogeny may be shortened and simplified, and many ancestral characters may be lost entirely. The result of the continued operation of retardation is retrogression, since the loss of the characters of nearer ancestors, with the continued repetition in early ontogeny of the characters of remote ancestors, must eventually cause the species to resemble the remote, rather than the nearer, ancestors.

II

Of the numerous cases adduced by paleontologists, in which there is clear evidence of recapitulation, I shall mention a few only.

Probably the best known examples of recapitulation are those made known by the researches of Hyatt, Branco, Würtenburger, Buckman, Smith and others among the Cephalopoda. It is shown that Ammonites pass through a goniatite stage, and that, as phrased by Zitttel, "The inner whorls of an ammonite constantly resemble in form, ornament and suture line the adult condition of some previously existing genus or other." The nautilus grows at first straight or orthoceraform, then arched or cyrtoceraform, and finally at the close of the first volution of the shell, becomes close coiled. The impressed zone appears in ancient nautiloidea in the neanic stage, where the whorls first come into contact, and is indeed a *result* of contact. In modern nautilus, and in Mesozoic and Tertiary nautilus the impressed zone appears in

the nepionic stage, *before the whorls come into contact.* It has been carried back in the ontogeny by acceleration. Smith concludes from a study of the development and phylogeny of *Placenticeras,* an Upper Cretaceous ammonoid, that "the development of *Placenticeras* shows that it is possible, in spite of dogmatic assertions to the contrary, to decipher the race history of an animal in its individual ontogeny."

Among the Gastropoda, Grabau and Burnett Smith have pointed out numerous beautiful cases of recapitulation. In *Fusus* and its allies, the higher forms quite constantly resemble in their earlier stages the adults of ancestral forms. Even in profoundly modified gerontic types, the young resemble the ancestors. Smith has brought to light in *Athleta* (*Volutilithes*) of the Eocene, an almost perfect example of even and regular acceleration, with its correlative, the recapitulation in the young of the Upper Eocene forms of the adult characters of the Lower Eocene forms. The stages passed through by this group of shells are, beginning with the earliest, a *smooth, curved rib, cancellated, spiny* and sometimes a *senile* stage. In the ancestral species (*A. limopsis*) the curved rib stage comes in at the close of the fourth whorl, whereas in the Upper Eocene form (*A. petrosa*), this stage comes in at the beginning of the third whorl.

Among the Pelecypoda the classic researches of Jackson are familiar to all. He shows that the modern *Pecten* passes through, in its ontogeny, a series of stages resembling adult *Rhombopteria, Pterinopecten* and *Aviculopecten,* and that the geologic order of these genera is the same as the ontogenetic order in *Pecten.* In such monomyarian genera as *Ostrea,* the initial shell, or prodissoconch, is dimyarian, and resembles the primitive *Nucula.* Again, in various more or less widely separated genera, the condition of complete cemented fixation has produced the ostreaform shape. Each one of these genera, however, except where the modification of shape due to fixation appears very early in ontogeny, recapitulates the adult characters of its respective ancestor. The examples of this are *Mulleria,* a member of the Unionidæ—like *Anodon* in the young; *Hinnites,* a member of the Pectinacea—like *Pecten* in the young; Spondylus, another member of the Pectinacea—like *Pecten* in the young.

Beecher's various studies of the Brachiopoda not only brought out the fact that the initial shell or protegulum of the brachiopod is remarkably similar to the most primitive known Lower Cambrian brachiopods, but have supplied in addition numerous other remarkable examples of recapitulation. One of the most striking of these is the case of the Terebratellidæ. In both the boreal and austral subfamilies a very complete series of genera correspond to the ontogenetic stages of the terminal or highest genera. Another interesting case is that of *Orbiculoidea.* This discoid shell has at first a straight hinge like *Iphidea.*

It next resembles *Obolella,* then at a later stage it is like *Schizocrania,* and finally adult growth brings in the characters of *Orbiculoidea.* Raymond has shown the remarkable similarity of the neanic stage of *Spirifer mucronatus* to the adult *S. crispus* of the Niagara. Shimer and Grabau found in the upper Hamilton of Thedford, Ontario, a variety of *Spirifer mucronatus* that is very mucronate in the young and not at all so in the adult. The derivation of this form from *S. mucronatus* is beyond question. I have pointed out a precisely similar case in *Platystrophia acutilirata* var. *senex.* This variety, which occurs in the upper Whitewater beds of Indiana and Ohio, has a hinge angle of nearly 90° in the adult. In the young, however, the outlines of the shell are exactly like the typical *P. acutilirata,* from which it is beyond any question descended. Greene has shown that *Chonetes granulifer* of the Carboniferous is, in the neanic stage, like the Devonian *Chonetes,* and that the hinge-spines come in at a considerably earlier stage in the Carboniferous than in the Devonian and Silurian forms, showing the acceleration of this character.

In the Bryozoa I have pointed out the fact that the colony behaves as an individual, and like an individual recapitulates in its ontogeny (astogeny) ancestral characters. This is beautifully shown in *Fenestella,* in which the earlier zoœcia are strikingly like the adult zoœcia of the Cyclostomata. The adolescent zoœcia of Devonian *Fenestella* are similar to the adult zoœcia of Niagara forms. Lang has brought together numerous cases of recapitulation among Jurassic and Cretaceous *Stomatopora* and *Proboscina.* The method of dichotomy in the earlier portions of the colony is constantly more like the normal dichotomy of ancestral species.

In graptolites the remarkable researches of Ruedemann clearly indicate that the graptolite colony recapitulates ancestral characters, the proximal thecæ being similar to ancestral adult thecæ. He says:

> The rhabdosomes in toto and their parts, the branches, seem also to pass through stages which suggest phylogenetically preceding forms.

Among the trilobites the studies of Beecher, Walcott and Matthew are classic. Beecher has shown that there is a common larval form, the protaspis, and that in higher genera characters appear in the protaspis that are known only in the adults of more primitive genera. For example, the " main features of the cephalon in the simple protaspis forms of *Solenopleura, Liostracus* and *Ptychoparia* are retained to maturity in such genera as *Carausia* and *Acontheus.*" Larval *Sao* has characters that occur in the adult of *Ctenocephalus.* The larval stages of *Dalmanites* and *Proetus* have characters that appear only in the adult of ancient genera.

Among the corals Beecher and Girty show that such genera as *Favosites* have early stages that suggest *Aulopora.* Lang, in a recent

paper, records very interesting cases of recapitulation in the genus *Parasmilia* of the Cretaceous. Bernard concludes that the coral colony, like the graptolite colony and the bryozoan colony, behaves as an individual.

In the echinoderms the likeness of the stem ossicles and the development of the anal plate of *Antedon,* to Paleozoic and Mesozoic forms has become one of the stock illustrations of recapitulation. Jackson has found interesting examples of recapitulation in the development of the ambulacral and inter-ambulacral plates of echinoids. Miss Smith has shown that the young *Pentremites* is exactly similar in form to the adult *Codaster.* This is an extremely interesting case, for Bather has independently, and from quite different data, come to the conclusion that *Pentremites* is derived from *Codaster.*

The idea of recapitulation has been one of the most fertile in the whole realm of biology, and its usefulness to the paleobiologist has been almost incalculable. But while there can be no doubt that recapitulation is a fact, the paleontologist should observe all due care not to assume too much for it. That there are various sorts of adaptations, arising at all stages of life, and that these may greatly obscure the ancestral record, is a fact too well known to require more than mention. There is also always acceleration, sometimes affecting different characters very unequally; and there may be retardation. All of these factors complicate the record of ontogeny. Nevertheless, after all of these have been taken duly into consideration, the parallel between ontogeny and phylogeny remains a powerful aid to investigation for the paleontologist.

VERTEBRATE PALEONTOLOGY AND THE EVIDENCES FOR RECAPITULATION

By L. HUSSAKOF

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AFTER the careful papers of Professors Loomis and Lull in which the doctrine of recapitulation was so fully set forth from the standpoint of vertebrate paleontology, I can perhaps do no better than devote part of the time allotted me to showing how certain leading vertebrate paleontologists have viewed this question. Then I will cite one or two illustrations of this principle drawn from among the lower vertebrates.

Passing over the period of pre-Darwinian paleontology—the paleontology of Cuvier, Owen and Louis Agassiz—we come to the time of Leidy, who, as Professor Osborn has recently shown,[1] was one of the first,

[1] In his address on "Darwin and Paleontology" printed in "Fifty Years of Darwinism." Centennial addresses in honor of Charles Darwin, New York, 1909, p. 209.

if not the first, to bring the fruits of paleontology to the support of evolution. But Leidy, as far as a hasty search through his writings could reveal, nowhere expressly advocated the doctrine of recapitulation. Indeed, he gave but little attention to the philosophical bearings of paleontology, generally partly because of temperament and partly because in those pioneer days material to serve as a basis for generalization was still scanty.

Gaudry, one of the first European paleontologists to champion the cause of evolution,[2] likewise did not specially advocate the doctrine of recapitulation. An examination of his "Philosophie Paleontologique" fails to reveal any definite belief in this doctrine.

Huxley, as far as I can gather from his papers and essays, believed in this doctrine, though with certain implied reservations as to its general applicability. In his presidential address to the Geological Society of London on "Paleontology and the Doctrine of Evolution" delivered in 1870, we find some interesting comment on the significance of the splints of the living horse, which he regards as indicative of the presence of three complete digits in the horse ancestor. But Huxley was never an out-and-out advocate of the biogenetic law.

Cope and Marsh, as we all know, were staunch upholders of evolution; and Cope, at least, was also a staunch upholder of the doctrine of recapitulation. In his "Primary Factors of Organic Evolution," his last contribution to philosophical paleontology, he devotes considerable space to proving this doctrine. He says:[3]

> The representatives of each class passed through the stages which are permanent in the classes below them in the series.

And he backs up this proposition with evidence derived from the ontogeny and phylogeny of batrachia, the antlers of deer and the blood trunks of vertebrates generally. For all that, Cope recognized the justice of certain criticisms which had been brought against the doctrine of recapitulation and urged caution in its application.

An example or two of recapitulation may now be cited from the field of the lower vertebrates.

The mode of development of the teeth in *Neoceratodus* has sometimes been adduced as an illustration of recapitulation. It is well known that the Devonic dipnoans (*e. g., Dipterus*) had teeth composed of rows of denticles, those in each row being more or less fused at their bases. During the history of the dipnoans since the Devonic period, the separate denticles have merged more and more until in *Ceratodus* and the living *Neoceratodus,* the rows of denticles are, in

[2] According to a letter from Darwin to Gaudry dated January 21, 1868. "The Life and Letters of Charles Darwin," edited by his son Francis Darwin, New York, 1899, Vol. II., p. 269.

[3] "Primary Factors of Organic Evolution," Chicago, 1896, p. 195.

the adult, replaced by almost smooth ridges. Now, Semon in his beautiful studies on the development of *Neoceratodus*[4] has shown that the teeth of this fish at one stage in ontogeny, are represented by rows of denticles even more discrete than the denticles in the Devonic *Dipterus;* then the denticles gradually merge at their bases, the separate cusps, however, still showing—a stage comparable with the Carboniferous *Ctenodus;* then they merge still more and assume the ridge-like form seen in the adult *Neoceratodus.*

Another example: In many sharks the alimentary canal is longer in the embryo than in the adult, the anal opening being situated near the posterior end of the trunk. From such cases one is inclined to believe that in the ancestral sharks this must have been the condition in the adult form; that is to say, the anal opening probably was near the posterior termination of the trunk. We may therefore ask: are there any early fossil sharks which show such a condition? Recently Professor Dean has described[5] a remarkable specimen of *Cladoselache* from the Upper Devonic of Ohio which seems to indicate such a condition. In this specimen remnants of both kidneys are preserved. They extend in the posterior half of the fish and by their direction indicate that they were drawn together, toward their external opening, not far from the posterior termination of the trunk. This shows that the anal opening in this ancestral shark was very much as in the early shark embryo to-day.

In conclusion perhaps I may venture to make one other point in regard to this question. A vast amount of skepticism concerning the doctrine of recapitulation is to be found in the literature of to-day; and if we study the reasons for this skepticism we find that it is in some measure justified. It is clearly established that among vertebrates as well as among invertebrates there are many examples of structures appearing during embryonic growth which are identical with structures found in the adult of some remote ancestor. But when we reflect on the amount of adaptation which any embryo has undergone in its long evolutional history; when we remember how palingenetic characters are on every hand overlaid by cenogenetic ones; who will say that recapitulation is a principle of general application, or that it is safe to draw conclusions from all embryos concerning their long extinct ancestors? Who will believe that a bony fish which runs through its embryonic development in a few days repeats its ancestral history, when we see at every stage of its ontogeny how it has been adaptively modified for this and for that special need? Only when series of related forms have certain onto-

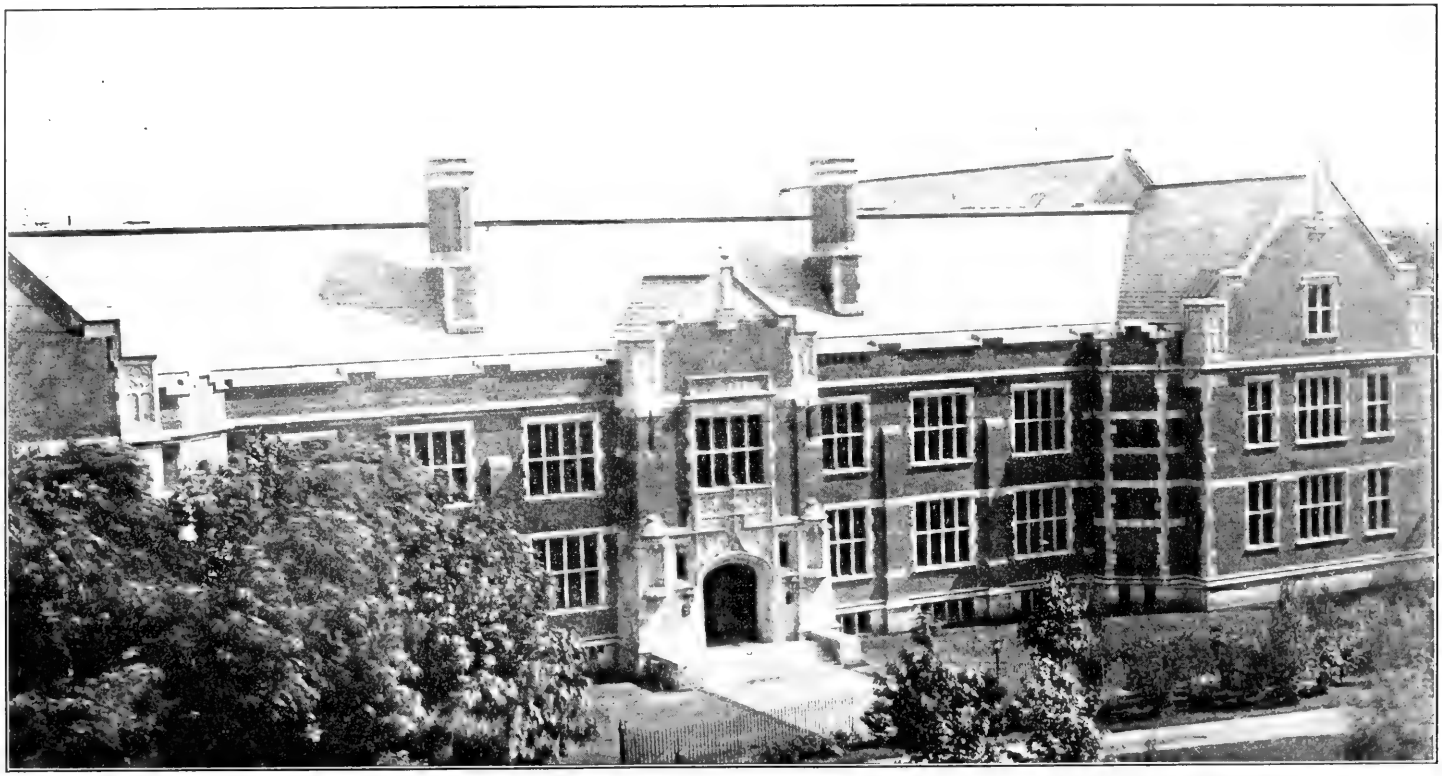
[4] "Die Zahnentwickelung des *Ceratodus forsteri*," "Zool. Forsch. in Austral. u. Malay. Archipel.," 1899, pp. 115–135, pls. xviii–xx.

[5] *Mem. Amer. Mus. Nat. Hist.*, Vol. IX., p. 232.

genetic stages in common are we justified in inferring that their racial ancestor may have had such characters in the adult state. But it should never be lost sight of that this inference is only a provisional hypothesis which may or may not be verified when the paleontologic record is more complete. It is no surprise that the efforts of some earnest paleontologists have been discredited in some quarters, especially among zoologists. Some of them have invoked recapitulation as a sort of magic spell by which they can conjure up ancestral forms from almost any embryonic series, forgetting the limitations of this doctrine. As far as the attitude of vertebrate paleontologists is concerned, their view has been aptly summarized by Professor Charles Depéret in his book "Les Transformations du Monde Animal" and I can do no better than close with a quotation from him:

> If we appeal to paleontology, it must be recognized that this hypothesis [recapitulation] is by no means verified. There do exist here and there certain fossil genera, which all their lives have retained certain youthful characteristics apparent in their living descendants; but when it comes to reconstructing whole series chronologically continuous, grave contradictions are met with, and it is only in the groups of the mammals and perhaps of the reptiles [and, we may add, fishes] that it becomes possible to present a few examples sufficiently demonstrative.[6]

[6] "Les Transformations du Monde Animal," Paris, 1907, p. 117.



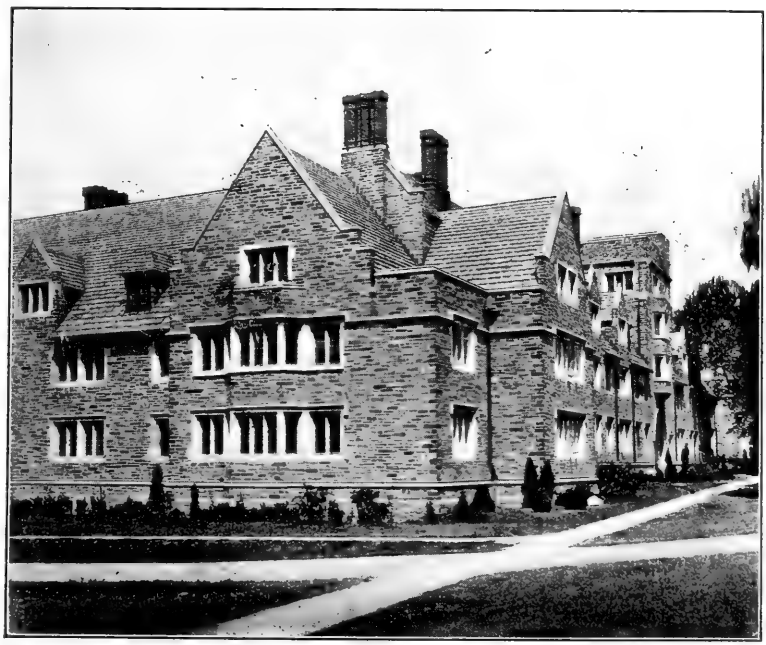
The Palmer Physical Laboratory.

THE PROGRESS OF SCIENCE

THE SCIENTIFIC LABORATORIES OF PRINCETON UNIVERSITY

THE colleges first established in this country prior to the revolution, apart from the two in Virginia, have all become great universities within the past forty years. Harvard, Yale, Columbia and Pennsylvania have preceded Princeton in this development, and for a period it was doubtful whether Princeton should be ranked among the universities or among the colleges. When, on the occasion of its sesquicentennial celebration in 1896, the official name of the College of New Jersey was changed to Princeton University, it was not so much a measure of what had been accomplished as a promise of things hoped for but unseen. The prophecy is now, however, in course of fulfilment. Princeton, it is true, has no professional schools, except its departments of civil and electrical engineering. A law school was once established, but it lasted only two years. No school of medicine is in contemplation, though the first two years of a medical course could be given to advantage. The theological seminary in the village has supplied a large proportion of the students registered in the graduate department, but it has no official connection with the university and is too narrowly denominational to be regarded as a graduate school of theology.

In most of our universities, however, the professional schools scarcely form an integral part of the institution and the graduate school is the place in which university and research work is accomplished. Such work has been



HOLLER HALL, a dormitory erected by Mrs. Sage.

GUYOT HALL.

gradually developed at Princeton in the course of the past few years, and there is likely to be now a mutation which will place the university among those where productive scholarship and creative research are most cultivated. The difficulties in regard to the graduate school which have been so widely exploited are in fact rather trivial and are now fairly solved, as the university has not only money for a residence hall but also for the men who are the real university. The Swan bequest of $300,000, the gift of $500,000 from Mr. Proctor, once withdrawn but now renewed, and the Wyman bequest, amounting probably to over $2,000,000, are all for the graduate school and give it a free endowment scarcely equaled at any other university.

Like all our institutions Princeton has spent relatively too much money on buildings and too little on men. But the money has come freely and the architectural setting at Princeton will appeal to the alumni and to the general public as the worthy exterior manifestation of a great university. It is also true that Princeton has done much for its men. In the preceptorial system it has undertaken to extend the personal contact between teacher and student which is one of the most marked advantages in the teaching of the sciences, to the departments not having laboratories, and has brought to Princeton some fifty selected men of the younger generation with the rank of assistant professors. The method adopted may be open to certain criticisms, but this group of men has added greatly to the strength of the university. In the meanwhile the laboratory departments have been developed both by buildings and by men. The department of physics has been made one of the strongest in the country and one of our leading zoologists has been called as head of the department of biology.

The buildings recently erected for physics and for natural science are shown in the accompanying illustrations. In both of them the academic Gothic style has been well adapted to laboratory construction. The Palmer

Physical Laboratory, erected and equipped by Mr. S. S. Palmer, and endowed with $200,000 by Mr. D. B. Jones and Mr. T. D. Jones, is admirably adapted for work in physics and electrical engineering. The three floors have an area of approximately two acres for the work of instruction and research, and every need in the way of appliances and apparatus is provided.

Guyot Hall, completed last year at a cost of $425,000, is divided about equally between biology and geology, giving the latter science probably the best provision in the country. The building contains over a hundred rooms, including a large museum. Biology has in addition a separate building as a vivarium for the study of living plants and animals. The aquaria have both sea and fresh water, and there is provision for insects, amphibians, reptiles, birds and mammals. Near by is a pond and stream where animals may be kept under natural conditions.

Princeton offers opportunities for study and research in the natural and exact sciences which are in some ways unique. The situation in the country, but within easy reach of New York and Philadelphia, offers many advantages. With its peculiar attractions, Princeton takes its place with the great universities so closely lining the eastern seaboard—Harvard, Yale, Columbia, Princeton, Pennsylvania and the Johns Hopkins.

COMPARATIVE PSYCHOLOGY IN AMERICA

THE last number of the *Zeitschrift für Psychologie* devotes twenty-two pages to a review of the recent literature of comparative psychology. This review covers more or less adequately the material for the years 1907, 1908 and 1909. Twenty-eight articles are noted of which nineteen are by American authors, one by an Englishman and the remaining eight by Germans.

This review emphasizes the fact that comparative psychology is largely an American branch of science. It began, in so far as the study of higher animal forms in this country is concerned, in 1898, with the classical work of Thorndike on "Animal Intelligence," which was followed three years later by his study of the "Mental Life of the Monkeys." Shortly afterwards small comparative laboratories were added to the already existing experimental laboratories of Clark, Harvard and Chicago, and in these the great bulk of the animal work has since been done. Recently a fairly adequate animal-behavior laboratory has been added to the psychological department of the Johns Hopkins University. It has been an interesting fact in the development of this field that the work has not been confined wholly to specially developed technical laboratories. Several important pieces of work have appeared under psychological auspices from the universities of Cornell, Illinois and Stanford and from the zoological laboratories of the universities of Chicago, Harvard and Johns Hopkins, and of the Carnegie Institution.

The work in this country has been characterized by systematic and long-continued studies of certain groups of problems; while that in foreign countries has been more sporadic. The work of Pfangst on "Der kluge Hans," which has been translated by Mr. Carl Rahn and that of Katz and Révész on the light sense of the chick are the two conspicuous examples of systematic and careful work in Germany. In the United States work has been centered around three problems: (1) the general method of learning (problem boxes, mazes, etc.) which gives acquaintance with the animal's instinctive capacities and prepares the way for a study of (2) imitation (and the effect of tuition) and (3) the determination of the delicacy and completeness of its sense-organ equipment.

The first problem received the greatest amount of attention during the first

few years. We now know something at least of the learning process, to mention mammals alone, of several of the monkeys (Thorndike, Kinneman, Watson, Haggerty); dogs and cats (Thorndike, Hamilton); raccoons (Davis and Cole); the rat (Small, Watson, Berry, Richardson); the dancing mouse (Yerkes); the guinea-pig (Allen) and the grey squirrel (Yoakum). Other forms have not been neglected, and we have to-day as a result of the ten years' work a fairly respectable body of knowledge on the learning methods and capacities of animal forms ranging from the amœba to man. This work has shown that even the lowest organisms possess plasticity. Jennings has been chiefly responsible for challenging the continental idea (Loeb, Bethe, Beer, Bohn and others) that the behavior of the invertebrates is of the fixed and non-plastic type.

The second problem, that of imitation, has been largely studied. Unfortunately the work in this direction has been characterized by a marked difference in experimental results. Thorndike (dogs, cats, monkeys) and Watson (monkeys) have been convinced by their results that learning by imitation is not an important function in animal adjustment. Haggerty (monkeys), Porter (birds) and Berry (rat, and manx cat) reach opposite conclusions. Haggerty's recent work on the chimpanzee and ourang shows clearly that imitation of a complex character is present in the anthropoid apes. There is still room for doubt in the case of other animal forms.

Careful work on the sensory equipment of animals is only just beginning. The American Psychological Association has appointed a committee for the determination of standard methods of testing vision in animals. The appearance of this report will probably lead to renewed interest in this problem. It ought to have the effect of making the work of the different investigators directly comparable and to lead to safe conclusions concerning the phylogenetic development of sense organ processes.

In conclusion, the renewed interest in field observation may be mentioned. The establishment of laboratories for the study of animal behavior at first drew interest away from field work. Recently animal psychologists have been forced to admit partially the truth of the claims of Wesley Mills, John Burroughs, Hobhouse and Morgan, viz., that animal experimentation ought not to be carried out under too rigorous and unnatural conditions. Studies in the field in the last ten years have been made by the Peckhams (insects), Newman (amphibia) and Watson (birds). Interesting possibilities in field observation are offered in studies of the beaver, the prairie dog and lizards.

SCIENTIFIC ITEMS

We regret to record the deaths of Dr. Johann Gottfried Galle, the eminent German astronomer, at the age of ninety-eight years, and of the Rev. Robert Harley, F.R.S., an English congregational clergyman, known for his contributions to mathematics and symbolic logic, at the age of eighty-three years.

At a meeting of the Berlin Academy of Sciences on June 30, commemorative addresses were made on Friedrich Kohlrausch, by Professor Rubens; on Hans Landolt, by Professor van't Hoff, and on Robert Koch, by Professor Rubner.—On October 2 the unveiling of the statue of Johann Gregor Mendel will take place at Gregor-Mendel-Platze in Altbrünn.—A tablet in memory of Richard Hakluyt, the navigator, was unveiled in Bristol Cathedral on July 7, the address being made by Sir Clements Markham.

THE
POPULAR SCIENCE
MONTHLY

OCTOBER, 1910

ADDRESS BEFORE THE NATIONAL CONSERVATION CONGRESS

By President WILLIAM H. TAFT

CONSERVATION as an economic and political term has come to mean the preservation of our natural resources for economical use, so as to secure the greatest good to the greatest number. In the development of this country, in the hardships of the pioneer, in the energy of the settler, in the anxiety of the investor for quick returns, there was very little time, opportunity, or desire to prevent waste of those resources supplied by nature which could not be quickly transmuted into money; while the investment of capital was so great a desideratum that the people as a community exercised little or no care to prevent the transfer of absolute ownership of many of the valuable natural resources to private individuals, without retaining some kind of control of their use.

The impulse of the whole new community was to encourage the coming of population, the increase of settlement, and the opening up of business; and he who demurred in the slightest degree to any step which promised additional development of the idle resources at hand was regarded as a traitor to his neighbors and an obstructor to public progress. But now that the communities have become old, now that the flush of enthusiastic expansion has died away, now that the would-be pioneers have come to realize that all the richest lands in the country have been taken up, we have perceived the necessity for a change of policy in the disposition of our national resources so as to prevent the continuance of the waste which has characterized our phenomenal growth in the past. To-day we desire to restrict and retain under public control the acquisition and use by the capitalists of our natural resources.

The danger to the state and to the people at large from the waste

and dissipation of our national wealth is not one which quickly impresses itself on the people of the older communities, because its most obvious instances do not occur in their neighborhood, while in the newer part of the country, the sympathy with expansion and development is so strong that the danger is scoffed at or ignored. Among scientific men and thoughtful observers, however, the danger has always been present; but it needed some one to bring home the crying need for a remedy of this evil so as to impress itself on the public mind and lead to the formation of public opinion and action by the representatives of the people. Theodore Roosevelt took up this task in the last two years of his second administration, and well did he perform it.

As president of the United States, I have, as it were, inherited this policy, and I rejoice in my heritage. I prize my high opportunity to do all that an executive can do to help a great people realize a great national ambition. For conservation is national. It affects every man of us, every woman, every child. What I can do in the cause I shall do, not as president of a party, but as president of the whole people.

Conservation is not a question of politics, or of factions, or of persons. It is a question that affects the vital welfare of all of us—of our children and our children's children. I urge that no good can come from meetings of this sort unless we ascribe to those who take part in them, and who are apparently striving worthily in the cause, all proper motives, and unless we judicially consider every measure or method proposed with a view to its effectiveness in achieving our common purpose, and wholly without regard to who proposes it or who will claim the credit for its adoption. The problems are of very great difficulty and call for the calmest consideration and clearest foresight. Many of the questions presented have phases that are new in this country, and it is possible that in their solution we may have to attempt first one way and then another. What I wish to emphasize, however, is that a satisfactory conclusion can only be reached promptly if we avoid acrimony, imputations of bad faith, and political controversy.

The public domain of the government of the United States, including all the cessions from those of the thirteen states that made cessions to the United States and including Alaska, amounted in all to about 1,800,000,000 acres. Of this there is left as purely government property outside of Alaska something like 700,000,000 of acres. Of this the national forest reserves in the United States proper embrace 144,000,000 acres. The rest is largely mountain or arid country, offering some opportunity for agriculture by dry farming and by reclamation, and containing metals as well as coal, phosphates, oils and natural gas. Then the government owns many tracts of land lying along the margins of streams that have water power, the use of which is necessarily in the conversion of the power into electricity and its transmission.

I shall divide my discussion under the heads of (1) agricultural lands; (2) mineral lands—that is, lands containing metalliferous minerals; (3) forest lands; (4) coal lands; (5) oil and gas lands; and (6) phosphate lands.

I feel that it will conduce to a better understanding of the problems presented if I take up each class and describe, even at the risk of tedium, first, what has been done by the last administration and the present one in respect to each kind of land; second, what laws at present govern its disposition; third, what was done by the present congress in this matter; and fourth, the statutory changes proposed in the interest of conservation.

Agricultural Lands

Our land laws for the entry of agricultural lands are now as follows:

The original homestead law, with the requirements of residence and cultivation for five years, much more strictly enforced than ever before.

The enlarged homestead act, applying to non-irrigable lands only, requiring five years' residence and continuous cultivation of one fourth of the area.

The desert-land act, which requires on the part of the purchaser the ownership of a water right and thorough reclamation of the land by irrigation, and the payment of $1.25 per acre.

The donation or Carey act, under which the state selects the land and provides for its reclamation, and the title vests in the settler who resides upon the land and cultivates it and pays the cost of the reclamation.

The national reclamation homestead law, requiring five years' residence and cultivation by the settler on the land irrigated by the government, and payment by him to the government of the cost of reclamation.

There are other acts, but not of sufficient general importance to call for mention unless it is the stone and timber act, under which every individual, once in his lifetime, may acquire 160 acres of land, if it has valuable timber on it or valuable stone, by paying the price of not less than $2.50 per acre fixed after examination of the stone or timber by a government appraiser. In times past a great deal of fraud has been perpetrated in the acquisition of lands under this act; but it is now being much more strictly enforced, and the entries made are so few in number that it seems to serve no useful purpose and ought to be repealed.

The present congress passed a bill of great importance, severing the ownership of coal by the government in the ground from the surface and permitting homestead entries upon the surface of the land which, when perfected, give the settler the right to farm the surface, while the coal beneath the surface is retained in ownership by the government and may be disposed of by it under other laws.

There is no crying need for radical reform in the methods of disposing of what are really agricultural lands. The present laws have worked well. The enlarged homestead law has encouraged the successful farming of lands in the semi-arid regions. Of course, the teachings of the agricultural department as to how these sub-arid lands may be treated and the soil preserved for useful culture are of the very essence of conservation. Then conservation of agricultural lands is shown in the reclamation of arid lands by irrigation, and I should devote a few words to what the government has done and is doing in this regard.

Reclamation

By the reclamation act a fund has been created of the proceeds of the public lands of the United States with which to construct works for storing great bodies of water at proper altitudes, from which, by a suitable system of canals and ditches, the water is to be distributed over the arid and sub-arid lands of the government to be sold to settlers at a price sufficient to pay for the improvements. Primarily, the projects are and must be for the improvement of public lands. Incidentally, where private land is also within the reach of the water supply, the furnishing at cost or profit of this water to private owners by the government is held by the federal court of appeals not to be a usurpation of power. But certainly this ought not to be done except from surplus water, not needed for government land.

About thirty projects have been set on foot distributed through the public land states in accord with the statute, by which the allotments from the reclamation fund are required to be as near as practicable in proportion to the proceeds from the sale of the public lands in the respective states. The total sum already accumulated in the reclamation fund is $60,273,258.22, and of that all but $6,491,955.34 has been expended.

It became very clear to congress at its last session, from the statements made by experts, that these thirty projects could not be promptly completed with the balance remaining on hand or with the funds likely to accrue in the near future. It was found, moreover, that there are many settlers who have been led into taking up lands with the hope and understanding of having water furnished in a short time, who are left in a most distressing situation. I recommended to congress that authority be given to the secretary of the interior to issue bonds in anticipation of the assured earnings by the projects, so that the projects, worthy and feasible, might be promptly completed and the settlers might be relieved from their present inconvenience and hardship. In authorizing the issue of these bonds, congress limited the application of their proceeds to those projects which a board of army engineers, to be appointed by the president, should examine and determine to be

feasible and worthy of completion. The board has been appointed and soon will make its report.

Suggestions have been made that the United States ought to aid in the drainage of swamp lands belonging to the states or private owners, because, if drained, they would be exceedingly valuable for agriculture and contribute to the general welfare by extending the area of cultivation. I deprecate the agitation in favor of such legislation. It is inviting the general government into contribution from its treasury toward enterprises that should be conducted either by private capital or at the instance of the state. In these days there is a disposition to look too much to the federal government for everything. I am liberal in the construction of the constitution with reference to federal power; but I am firmly convinced that the only safe course for us to pursue is to hold fast to the limitations of the constitution and to regard as sacred the powers of the states. We have made wonderful progress and at the same time have preserved with judicial exactness the restrictions of the constitution. There is an easy way in which the constitution can be violated by congress without judicial inhibition, to wit, by appropriations from the national treasury for unconstitutional purposes. It will be a sorry day for this country if the time ever comes when our fundamental compact shall be habitually disregarded in this manner.

Mineral Lands

By mineral lands I mean those lands bearing metals, or what are called metalliferous minerals. The rules of ownership and disposition of these lands were first fixed by custom in the west, and then were embodied in the law, and they have worked, on the whole, so fairly and well that I do not think it is wise now to attempt to change or better them. The apex theory of tracing title to a lode has led to much litigation and dispute and ought not to have become the law, but it is so fixed and understood now that the benefit to be gained by a change is altogether outweighed by the inconvenience that would attend the introduction of a new system. So, too, the proposal for the government to lease such mineral lands and deposits and to impose royalties might have been in the beginning a good thing, but now that most of the mineral land has been otherwise disposed of it would be hardly worth while to assume the embarrassment of a radical change.

Forest Lands

Nothing can be more important in the matter of conservation than the treatment of our forest lands. It was probably the ruthless destruction of forests in the older states that first called attention to a halt in the waste of our resources. This was recognized by congress by an act authorizing the executive to reserve from entry and set aside public

timber lands as national forests. Speaking generally, there has been reserved of the existing forests about 70 per cent. of all the timber lands of the government. Within these forests (including 26,000,000 acres in two forests in Alaska) are 192,000,000 of acres, of which 166,000,000 of acres are in the United States proper, and include within their boundaries something like 22,000,000 of acres that belong to the state or to private individuals. We have, then, excluding Alaska forests, a total of about 144,000,000 acres of forests belonging to the government which is being treated in accord with the principles of scientific forestry.

The law now prohibits the reservation of any more forest lands in Oregon, Washington, Idaho, Montana, Colorado and Wyoming, except by act of congress. I am informed by the department of agriculture that the government owns other tracts of timber land in these states which should be included in the forest reserves. I expect to recommend to congress that the limitation herein imposed shall be repealed.

In the present forest reserves there are lands which are not properly forest land, and which ought to be subject to homestead entry. This has caused some local irritation. We are carefully eliminating such lands from forest reserves, or where their elimination is not practicable, listing them for entry under the forest homestead act. Congress ought to trust the executive to use the power of reservation only with respect to land covered by timber or which will be useful in the plan of reforestation. During the present administration 6,250,000 acres of land, largely non-timbered, have been excluded from forest reserves, and 3,500,000 acres of land principally valuable for forest purposes have been included in forest reserves, making a reduction in forest reserves of non-timbered land amounting to 2,750,000 acres. The Bureau of Forestry since its creation has initiated reforestation on 5,600 acres.

A great deal of the forest land is available for grazing. During the past year the grazing lessees numbered 25,400, and they pastured upon the forest reserves 1,400,000 cattle, 84,540 horses and 7,580,400 sheep, for which the government received $986,715—a decrease from the preceding year of $45,470, due to the fact that no money was collected or received for grazing on the non-timbered lands eliminated from the forest reserve. Another source of profit in the forestry is the receipts for timber sold. This year they amounted to $1,043,000, an increase of $307,000 over the receipts of last year. This increase is due to the improvement in transportation to market and to the greater facility with which the timber can be reached.

The government timber in this country amounts to only one fourth of all the timber, the rest being in private ownership. Only 3 per cent. of that which is in private ownership is looked after properly and treated according to modern rules of forestry. The usual destructive waste and neglect continues in the remainder of the forests owned by

private persons and corporations. It is estimated that fire alone destroys fifty million dollars' worth of timber a year. The management of forests not on public land is beyond the jurisdiction of the federal government.

If anything can be done by law it must be done by the state legislatures. I believe that it is within their constitutional power to require the enforcement of regulations in the general public interest, as to fire and other causes of waste in the management of forests owned by private individuals and corporations. Exactly how far these regulations can go and remain consistent with the rights of private ownership, it is not necessary to discuss; but I call attention to the fact that a very important part of conservation must always fall upon the state legislatures, and that they would better be up and doing if they would save the waste and denudation and destruction through private greed or accidental fires that have made barren many square miles of the older states.

I have shown sufficiently the conditions as to federal forestry to indicate that no further legislation is needed at the moment except an increase in the fire protection to national forests, and an act vesting the executive with full power to make forest reservations in every state where government land is timber-covered, or where the land is needed for forestry purposes.

Other Land Withdrawals

When President Roosevelt became fully advised of the necessity for the change in our disposition of public lands, especially those containing coal, oil, gas, phosphates, or water-power sites, he began the exercise of the power of withdrawal by executive order, of lands subject by law to homestead and the other methods of entering for agricultural lands. The precedent he set in this matter was followed by the present administration. Doubt had been expressed in some quarters as to the power in the executive to make such withdrawals. The confusion and injustice likely to arise if the courts were to deny the power led me to appeal to congress to give the president the express power. Congress has complied. The law as passed does not expressly validate or confirm previous withdrawals, and therefore as soon as the new law was passed, I myself confirmed all the withdrawals which had theretofore been made by both administrations by making them over again. This power of withdrawal is a most useful one, and I do not think it is likely to be abused.

Coal Lands

The next subject, and one most important for our consideration, is the disposition of the coal lands in the United States and in Alaska. First, as to those in the United States. At the beginning of this ad-

ministration there were classified coal lands amounting to 5,476,000 acres, and there were withdrawn from entry for purposes of classification 17,867,000 acres. Since that time there have been withdrawn by my order from entry for classification 77,648,000 acres, making a total withdrawal of 95,515,000 acres. Meantime, of the acres thus withdrawn, 11,371,000 have been classified and found not to contain coal, and have been restored to agricultural entry and 4,356,000 acres have been classified as coal lands; while 79,788,000 acres remain withdrawn from entry and await classification. In addition 336,000 acres have been classified as coal lands without prior withdrawal, thus increasing the classified coal lands to 10,168,000 acres.

Under the laws providing for the disposition of coal lands, the minimum price at which lands are permitted to be sold is $10 an acre; but the secretary of the interior has the power to fix a maximum price and to sell at that price. By the first regulations governing appraisal, approved April 8, 1907, the minimum was $10, as provided by law, and the maximum was $100, and the highest price actually placed upon any land sold was $75. Under the new regulations, adopted April 10, 1909, the maximum price was increased to $300, except in regions where there are large mines, where no maximum limit is fixed, and the price is determined by the estimated tons of coal to the acre. The highest price fixed for any land under this regulation has been $608. The appraised value of the lands classified as coal lands and valued under the new and old regulations is shown to be as follows: 4,303,921 acres, valued under the old regulation at $77,644,329, an average of $18 an acre; and 5,864,702 acres classified and valued under the new regulation at $394,203,242, or a total of 10,168,623 acres, valued at $471,847,571.

For the year ending March 31, 1909, 227 coal entries were made, embracing an area of 35,331 acres, which sold for $663,020.40. For the year ending March 31, 1910, there were 176 entries, embracing an area of 23,413 acres, which sold for $608,813; and down to August, 1910, there were but 17 entries, with an area of 1,720 acres, which sold for $33,910.60, making a disposition of the coal lands in the last two years of about 60,000 acres for $1,305,000.

The present congress, as already said, has separated the surface of coal lands, either classified or withdrawn for classification, from the coal beneath, so as to permit at all times homestead entries upon the surface of lands useful for agriculture and to reserve the ownership in the coal to the government. The question which remains to be considered is whether the existing law for the sale of the coal in the ground should continue in force or be repealed, and a new method of disposition adopted. Under the present law the absolute title in the coal beneath the surface passes to the grantee of the government. The price fixed is upon an estimated amount of the tons of coal per acre beneath the

surface, and the prices are fixed so that the earnings will only be a reasonable profit upon the amount paid and the investment necessary. But, of course, this is more or less guesswork, and the government parts with the ownership of the coal in the ground absolutely.

Authorities of the Geological Survey estimate that in the United States to-day there is a supply of about 3,000 billions of tons of coal, and that of this, 1,000 billions are in the public domain. Of course, the other 2,000 billions are within private ownership, and under no more control as to the use or the prices at which the coal may be sold than any other private property. If the government leases the coal lands and acts as any landlord would, and imposes conditions in its leases like those which are now imposed by the owners in fee of coal mines in the various coal regions of the east, then it would retain over the disposition of the coal deposits a choice as to the assignee of the lease, a power of resuming possession at the end of the term of the lease, or of readjusting terms at fixed periods of the lease, which might easily be framed to enable it to exercise a limited but effective control in the disposition and sale of the coal to the public.

It has been urged that the leasing system has never been adopted in this country, and that its adoption would largely interfere with the investment of capital and the proper development and opening up of the coal resources. I venture to differ entirely from this view. My investigations show that many owners of mining property of this country do not mine it themselves, and do not invest their money in the plants necessary for the mining, but they lease their properties for a term of years varying from twenty to thirty and forty years, under conditions requiring the erection of a proper plant and the investment of a certain amount of money in the development of the mines, and fixing a rental and a royalty, sometimes an absolute figure and sometimes one proportioned to the market value of the coal. Under this latter method the owner of the mine shares in the prosperity of his lessees when coal is high and the profits good, and also shares to some extent in their disappointment when the price of coal falls.

I have looked with some care into a report made at the instance of President Roosevelt upon the disposition of coal lands in Australia, Tasmania and New Zealand. These are peculiarly mining countries, and their experience ought to be most valuable. In all these countries the method for the disposition and opening of coal mines originally owned by the government is by granting leasehold, and not by granting an absolute title. The terms of the leases run all the way from twenty to fifty years, while the amount of land which may be leased to any individual there is from 320 acres to 2,000 acres. It appears that a full examination was made, and the opinions of all the leading experts on the subject were solicited and given, and that with one accord they

approved in all respects the leasing system. Its success is abundantly shown. It is possible that at first considerable latitude will have to be given to the executive in drafting these forms of lease, but as soon as experiment shall show which is the most workable and practicable, its use should be provided for specifically by statute.

The question as to how great an area ought to be included in a lease to one individual or corporation is not free from difficulty; but in view of the fact that the government retains control as owner, I think there might be some liberality in the amount leased, and that 2,500 acres would not be too great a maximum.

By the opportunity to readjust the terms upon which the coal shall be held by the tenant, either at the end of each lease or at periods during the term, the government may secure the benefit of sharing in the increased price of coal and the additional profit made by the tenant. By imposing conditions in respect to the character of the work to be done in the mines, the government may control the character of the development of the mines and the treatment of employees with reference to safety. By denying the right to transfer the lease except by the written permission of the governmental authorities, it may withhold the needed consent when it is proposed to transfer the leasehold to persons interested in establishing a monopoly of coal production in any state or neighborhood. As one third of all the coal supply is held by the government, it seems wise that it should retain such control over the mining and the sale as the relation of lessor to lessee furnishes. The change from the absolute grant to the leasing system will involve a good deal of trouble in the outset, and the training of experts in the matter of making proper leases; but the change will be a good one, and can be made. The change is in the interest of conservation, and I am glad to approve it.

Alaska Coal Lands

The investigations of the geological survey show that the coal properties in Alaska cover about 1,200 square miles, and that there are known to be available about fifteen billion tons. This is, however, an underestimate of the coal in Alaska, because further developments will probably increase this amount many times; but we can say with considerable certainty that there are two fields on the Pacific slope which can be reached by railways at a reasonable cost from deep water—in one case of about fifty miles and in the other case of about 150 miles—which will afford certainly six billion tons of coal, more than half of which is of a very high grade of bituminous and of anthracite. It is estimated to be worth, in the ground, one half a cent a ton, which makes its value per acre from $50 to $500. The coking-coal lands of Pennsylvania are worth from $800 to $2,000 an acre, while other Appalachian fields are worth from $10 to $386 an acre, and the field in the central states from

$10 to $2,000 an acre, and in the Rocky Mountains $10 to $500 an acre. The demand for coal on the Pacific coast is for about 4,500,000 tons a year. It would encounter the competition of cheap fuel oil, of which the equivalent of 12,000,000 tons of coal a year is used there. It is estimated that the coal could be laid down at Seattle or San Francisco, a high-grade bituminous, at $4 a ton, and anthracite at $5 or $6 a ton. The price of coal on the Pacific slope varies greatly from time to time in the year and from year to year—from $4 to $12 a ton.

With a regular coal supply established, the expert of the geological survey, Mr. Brooks, who has made a report on the subject, does not think there would be an excessive profit in the Alaska coal mining because the price at which the coal could be sold would be considerably lowered by competition from these fields and by the presence of crude fuel oil. The history of the laws affecting the disposition of Alaska coal lands shows them to need amendment badly. Speaking of them, Mr. Brooks says:

"The first act, passed June 6, 1900, simply extended to Alaska the provisions of the coal-land laws in the United States. The law was ineffective, for it provided that only subdivided lands could be taken up, and there were then no land surveys in Alaska. The matter was rectified by the act of April 28, 1904, which permitted unsurveyed lands to be entered and the surveys to be made at the expense of the entrymen. Unfortunately, the law provided that only tracts of 160 acres could be taken up, and no recognition was given to the fact that it was impracticable to develop an isolated coal field requiring the expenditure of a large amount of money by such small units. Many claims were staked, however, and surveys were made for patents. It was recognized by everybody familiar with the conditions that after patent was obtained these claims would be combined in tracts large enough to assure successful mining operations. No one experienced in mining would, of course, consider it feasible to open a coal field on the basis of single 160-acre tracts. The claims for the most part were handled in groups, for which one agent represented the several different owners. Unfortunately, a strict interpretation of the statute raised the question whether even a tacit understanding between claim owners to combine after patents had been obtained was not illegal. Remedial legislation was sought and enacted in the statute of May 28, 1908. This law permitted the consolidation of claims staked previous to November 12, 1906, in tracts of 2,560 acres. One clause of this law invalidated the title if any individual or corporation at any time in the future owned any interest whatsoever, directly or indirectly, in more than one tract. The purpose of this clause was to prevent the monopolization of coal fields; its immediate effect was to discourage capital. It was felt by many that this clause might lead to forfeiture of title through the acci-

dents of inheritance, or might even be used by the unscrupulous in blackmailing. It would appear that land taken up under this law might at any time be forfeited to the government through the action of any individual who, innocently or otherwise, obtained interest in more than one coal company. Such a title was felt to be too insecure to warrant the large investments needed for mining developments. The net result of all this is that no titles to coal lands have been passed."

On November 12, 1906, President Roosevelt issued an executive order withdrawing all coal lands from location and entry in Alaska. On May 16, 1907, he modified the order so as to permit valid locations made prior to the withdrawal on November 12, 1906, to proceed to entry and patent. Prior to that date some 900 claims had been filed, most of them said to be illegal because either made fraudulently by dummy entrymen in the interests of one individual or corporation, or because of agreements made prior to location between the applicants to cooperate in developing the lands. There are 33 claims for 160 acres each, known as the "Cunningham claims," which are claimed to be valid on the ground that they were made by an attorney for 33 different and bona-fide claimants who, as alleged, paid their money and took the proper steps to locate their entries and protect them.

The representatives of the government in the hearings before the land office have attacked the validity of these Cunningham claims on the ground that prior to their location there was an understanding between the claimants to pool their claims after they had been perfected and unite them in one company. The trend of decision seems to show that such an agreement would invalidate the claims, although under the subsequent law of May 28, 1908, the consolidation of such claims was permitted, after location and entry, in tracts of 2,560 acres.

It would be, of course, improper for me to intimate what the result of the issue as to the Cunningham and other Alaska claims is likely to be, but it ought to be distinctly understood that no private claims for Alaska coal lands have as yet been allowed or perfected, and also that whatever the result as to pending claims, the existing coal-land laws of Alaska are most unsatisfactory and should be radically amended.

To begin with, the purchase price of the land is a flat rate of $10 per acre, although, as we have seen, the estimate of the agent of the geological survey would carry up the maximum of value to $500 an acre. In my judgment, it is essential in the proper development of Alaska that these coal lands should be opened, and that the Pacific slope should be given the benefit of the comparatively cheap coal of fine quality which can be furnished at a reasonable price from these fields; but the public, through the government, ought certainly to retain a wise control and interest in these coal deposits, and I think it may do so safely if congress will authorize the granting of leases, as already sug-

gested for government coal lands in the United States, with provisions forbidding the transfer of the leases except with the consent of the government, thus preventing their acquisition by a combination or monopoly and upon limitations as to the area to be included in any one lease to one individual, and at a certain moderate rental, with royalties upon the coal mined proportioned to the market value of the coal either at Seattle or at San Francisco. Of course, such leases should contain conditions requiring the erection of proper plants, the proper development by modern mining methods of the properties leased, and the use of every known and practical means and device for saving the lives of the miners.

The government of the United States has much to answer for in not having given proper attention to the government of Alaska and the development of her resources for the benefit of all the people of the country. I would not force development at the expense of a present or future waste of resources; but the problem as to the disposition of the coal lands for present and future use can be wisely and safely settled in one session if congress gives it careful attention.

Oil and Gas Lands

In the last administration there were withdrawn from agricultural entry 2,820,000 acres of supposed oil land in California; about a million and a half acres in Louisiana, of which only 6,500 acres were known to be vacant, unappropriated land; 75,000 acres in Oregon, and 174,000 acres in Wyoming, making a total of nearly four millions of acres. In September, 1909, I directed that all public oil lands, whether then withdrawn or not, should be withheld from disposition pending congressional action, for the reason that the existing placer mining law, although made applicable to deposits of this character, is not suitable to such lands, and for the further reason that it seemed desirable to reserve certain fuel-oil deposits for the use of the American navy. Accordingly the form of all existing withdrawals was changed, and new withdrawals aggregating 2,750,000 acres were made in Arizona, California, Colorado, New Mexico, Utah and Wyoming. Field examinations during the year showed that of the original withdrawals, 2,170,000 acres were not valuable for oil, and they were restored for agricultural entry. Meantime, other withdrawals of public oil lands in these states were made, so that July 1, 1910, the outstanding withdrawals then amounted to 4,550,000 acres.

The needed oil and gas law is essentially a leasing law. In their natural occurrence, oil and gas can not be measured in terms of acres, like coal and it follows that exclusive title to these products can normally be secured only after they reach the surface. Oil should be disposed of as a commodity in terms of barrels of transportable product

rather than in acres of real estate. This is, of course, the reason for the practically universal adoption of the leasing system wherever oil land is in private ownership. The government thus would not be entering on an experiment, but simply putting into effect a plan successfully operated in private contracts. Why should not the government as a land owner deal directly with the oil producer rather than through the intervention of a middleman to whom the government gives title to the land?

The principal underlying feature of such legislation should be the exercise of beneficial control rather than the collection of revenue. As not only the largest owner of oil lands, but as a prospective large consumer of oil by reason of the increasing use of fuel oil by the navy, the federal government is directly concerned both in encouraging rational development and at the same time insuring the longest possible life to the oil supply. The royalty rates fixed by the government should neither exceed nor fall below the current rates. But much more important than revenue is the enforcement of regulations to conserve the public interest so that the convenants of the lessees shall specifically safeguard oil fields against the penalties from careless drillings and of production in excess of transportation facilities or of market requirements.

One of the difficulties presented, especially in the California fields, is that the Southern Pacific Railroad owns every other section of land in the oil fields, and in those fields the oil seems to be in a common reservoir or series of reservoirs, communicating through the oil sands, so that the excessive draining of oil at one well, or on the railroad territory generally, would exhaust the oil in the government land. Hence it is important that if the government is to have its share of the oil it should begin the opening and development of wells on its own property.

In view of the joint ownership which the government and the adjoining land-owners like the Southern Pacific Railroad have in the oil reservoirs below the surface, it is a most interesting and intricate question, difficult of solution, but one which ought to address itself at once to the state lawmakers, how far the state legislature might impose appropriate restrictions to secure an equitable enjoyment of the common reservoir, and to prevent waste and and excessive drainage by the various owners having access to this reservoir.

It has been suggested, and I believe the suggestion to be a sound one, that permits be issued to a prospector for oil giving him the right to prospect for two years over a certain tract of government land for the discovery of oil, the right to be evidenced by a license for which he pays a small sum. When the oil is discovered, then he acquires title to a certain tract, much in the same way as he would acquire title under a mining law. Of course, if the system of leasing is adopted, then he

would be given the benefit of a lease upon terms like that above suggested. What has been said in respect to oil applies also to government gas lands.

Under the proposed oil legislation, especially where the government oil lands embrace an entire oil field, as in many cases, prospectors, operators, consumers and the public can be benefited by the adoption of the leasing system. The prospector can be protected in the very expensive work that necessarily antedates discovery; the operator can be protected against impairment of the productiveness of the wells which he has leased by reason of control of drilling and pumping of other wells too closely adjacent, or by the prevention of improper methods as employed by careless, ignorant or irresponsible operators in the same field which result in the admission of water to the oil sands; while, of course, the consumer will profit by whatever benefits the prospector or operator receives in reducing the first cost of the oil.

Phosphate Lands

Phosphorus is one of the three essentials to plant growth, the other elements being nitrogen and potash. Of these three, phosphorus is by all odds the scarcest element in nature. It is easily extracted in useful form from the phosphate rock, and the United States contains the greatest known deposits of this rock in the world. They are found in Wyoming, Utah and Florida, as well as in South Carolina, Georgia and Tennessee. The government phosphate lands are confined to Wyoming, Utah and Florida. Prior to March 4, 1909, there were 4,000,000 acres withdrawn from agricultural entry on the ground that the land covered phosphate rock. Since that time, 2,322,000 acres of the land thus withdrawn was found not to contain phosphate in profitable quantities, while 1,678,000 acres was classified properly as phosphate lands. During this administration there has been withdrawn and classified 437,000 acres, so that to-day there is classified as phosphate-rock land 2,115,000 acres.

This rock is most important in the composition of fertilizers to improve the soil, and as the future is certain to create an enormous demand throughout this country for fertilization, the value to the public of such deposits as these can hardly be exaggerated. Certainly with respect to these deposits a careful policy of conservation should be followed. Half of the phosphate of the rock that is mined in private fields in the United States is exported. As our farming methods grow better the demand for the phosphate will become greater, and it must be arranged so that the supply shall equal the needs of the country.

It is uncertain whether the placer or lode law applies to the government phosphate rock. There is, therefore, necessity for some definite and well-considered legislation on this subject, and in aid of such legis-

lation all of the government lands known to contain valuable phosphate rock are now withdrawn from entry. A law that would provide a leasing system for the phosphate deposits, together with a provision for the separation of the surface and mineral rights as is already provided for in the case of coal, would seem to meet the need of promoting the development of these deposits and their utilization in the agricultural lands of the west. If it is thought desirable to discourage the exportation of phosphate rock and the saving of it for our own lands, this purpose could be accomplished by conditions in the lease granted by the government to its lessees. Of course, under the constitution the government could not tax and could not prohibit the exportation of phosphate, but as proprietor and owner of the lands in which the phosphate is deposited it could impose conditions upon the kind of sales, whether foreign or domestic, which the lessees might make of the phosphate mined.

The tonnage represented by the phosphate lands in government ownership is very great, but the lesson has been learned in the case of such lands that have passed into private ownership in South Carolina, Florida and Tennessee that the phosphate deposits there are in no sense inexhaustible. Moreover, it is also well understood that in the process of mining phosphate, as it has been pursued, much of the lower grade of phosphate rock, which will eventually all be needed has been wasted beyond recovery. Such wasteful methods can easily be prevented, so far as the government land is concerned, by conditions inserted in the leases.

Water-power Sites

Prior to March 4, 1909, there had been, on the recommendation of the reclamation service, withdrawn from agricultural entry, because they were regarded as useful for power sites which ought not to be disposed of as agricultural lands, tracts amounting to about 4,000,000 acres. The withdrawals were hastily made and included a great deal of land that was not useful for power sites. They were intended to include the power sites on twenty-nine rivers in nine states. Since that time 3,475,442 acres have been restored for settlement of the original 4,000,000, because they do not contain power sites; and meantime there have been newly withdrawn 1,245,892 acres on vacant public land and 211,007 acres on entered public land, or a total of 1,456,899 acres. These withdrawals made from time to time cover all the power sites included in the first withdrawals, and many more, on 135 rivers and in 11 states.

The disposition of these power sites involves one of the most difficult questions presented in carrying out practical conservation. The forest service, under a power found in the statute, has leased a number of these power sites in forest reserves by revocable leases, but no such power exists with respect to power sites that are not located within forest

reserves, and the revocable system of leasing is, of course, not a satisfactory one for the purpose of inviting the capital needed to put in proper plants for the transmutation of power.

The statute of 1891 with its amendments permits the secretary of the interior to grant perpetual easements or rights of way from water sources over public lands for the primary purpose of irrigation and such electrical current as may be incidentally developed, but no grant can be made under this statute to concerns whose primary purpose is generating and handling electricity. The statute of 1901 authorizes the secretary of the interior to issue revocable permits over the public lands to electrical-power companies, but this statute is wofully inadequate because it does not authorize the collection of a charge or fix a term of years. Capital is slow to invest in an enterprise founded on a permit revocable at will.

The subject is one that calls for new legislation. It has been thought that there was danger of combination to obtain possession of all the power sites and to unite them under one control. Whatever the evidence of this, or lack of it, at present we have had enough experience to know that combination would be profitable, and the control of a great number of power sites would enable the holders or owners to raise the price of power at will within certain sections; and the temptation would promptly attract investors, and the danger of monopoly would not be a remote one.

However this may be, it is the plain duty of the government to see to it that in the utilization and development of all this immense amount of water power, conditions shall be imposed that will prevent monopoly, and will prevent extortionate charges, which are the accompaniment of monopoly. The difficulty of adjusting the matter is accentuated by the relation of the power sites to the water, the fall and flow of which create the power. In the states where these sites are the riparian owner does not control or own the power in the water which flows past his land. That power is under the control and within the grant of the state, and generally the rule is that the first user is entitled to the enjoyment. Now, the possession of the bank or water-power site over which the water is to be conveyed in order to make the power useful, gives to its owner an advantage and a certain kind of control over the use of the water power, and it is proposed that the government in dealing with its own lands should use this advantage and lease lands for power sites to those who would develop the power, and impose conditions on the leasehold with reference to the reasonableness of the rates at which the power, when transmuted, is to be furnished to the public, and forbidding the union of the particular power with a combination of others made for the purpose of monopoly by forbidding assignment of the lease save by consent of the government. Serious difficulties are

anticipated by some in such an attempt on the part of the general government, because of the sovereign control of the state over the water power in its natural condition, and the mere proprietorship of the government in the riparian lands.

It is contended that through its mere proprietary right in the site, the central government has no power to attempt to exercise police jurisdiction with reference to how the water power in a river owned and controlled by the state shall be used, and that it is a violation of the state's rights. I question the validity of this objection. The government may impose any conditions that it chooses in its lease of its own property, even though it may have the same purpose, and in effect accomplish just what the state would accomplish by the exercise of its sovereignty. There are those (and the director of the geological survey, Mr. Smith, who has given a great deal of attention to this matter, is one of them) who insist that that this matter of transmuting water power into electricity, which can be conveyed all over the country and across state lines, is a matter that ought to be retained by the general government, and that it should avail itself of the ownership of these power sites for the very purpose of coordinating in one general plan the power generated from these government-owned sites.

On the other hand, it is contended that it would relieve a complicated situation if the control of the water-power site and the control of the water were vested in the same sovereignty and ownership, viz., the states, and then were disposed of for development to private lessees under the restrictions needed to preserve the interests of the public from the extortions and abuses of monopoly. Therefore, bills have been introduced in congress providing that whenever the state authorities deem a water power useful they may apply to the government of the United States for a grant to the state of the adjacent land for a water-power site, and that this grant from the federal government to the state, shall contain a condition that the state shall never part with the title to the water-power site, or the water power, but shall lease it only for a term of years not exceeding fifty, with provisions in the lease by which the rental and the rates for which the power is furnished to the public shall be readjusted at periods less than the term of the lease, say, every ten years.

The argument is urged against this disposition of power sites that legislators and state authorities are more subject to corporate influence and control than would be the central government; in reply it is claimed that a readjustment of the terms of leasehold every ten years would secure to the public and the state just and equitable terms. Then it is said that the state authorities are better able to understand the local need and what is a fair adjustment in the particular locality than would be the authorities at Washington. It has been argued that after the

federal government parts with title to a power site it can not control the action of the state in fulfilling the conditions of the deed, to which it is answered that in the grant from the government there may be easily inserted a condition specifying the terms upon which the state may part with the temporary control of the water-power sites, and, indeed, the water power, and providing for a forfeiture of the title to the water-power sites in case the condition is not performed; and giving to the president, in case of such violation of conditions, the power to declare forfeiture and to direct proceedings to restore the central government to the ownership of the power sites with all the improvements thereon, and that these conditions may be promptly enforced and the land and plants forfeited to the general government by suit of the United States against the state, which is permissible under the constitution.

I do not express an opinion upon the controversy thus made or a preference as to the two methods of treating water-power sites. I shall submit the matter to congress and urge that one or the other of the two plans be adopted.

At the risk of wearying my audience I have attempted to state as succinctly as may be the questions of conservation as they apply to the public domain of the government, the conditions to which they apply, and the proposed solution of them. In the outset I alluded to the fact that conservation had been made to include a great deal more than what I have discussed here. Of course, as I have referred only to the public domain of the federal government I have left untouched the wide field of conservation with respect to which a heavy responsibility rests upon the states and individuals as well. But I think it of the utmost importance that after the public attention has been roused to the necessity of a change in our general policy to prevent waste and a selfish appropriation to private and corporate purposes of what should be controlled for the public benfit, those who urge conservation shall feel the necessity of making clear how conservation can be practically carried out, and shall propose specific methods and legal provisions and regulations to remedy actual adverse conditions.

I am bound to say that the time has come for a halt in general rhapsodies over conservation, making the word mean every known good in the world; for, after the public attention has been roused, such appeals are of doubtful utility, and do not direct the public to the specific course that the people should take, or have their legislators take, in order to promote the cause of conservation. The rousing of emotions on a subject like this, which has only dim outlines in the minds of the people affected, after a while ceases to be useful, and the whole movement will, if promoted on these lines, die for want of practical direction and of demonstration to the people that practical reforms are intended.

I have referred to the course of the last administration and of the present one in making withdrawals of government lands from entry under homestead and other laws and of congress in removing all doubt as to the validity of these withdrawals as a great step in the direction of practical conservation. But it is only one of two necessary steps to effect what should be our purpose. It has produced a status quo and prevented waste and irrevocable disposition of the lands until the method for their proper disposition can be formulated. But it is of the utmost importance that such withdrawals should not be regarded as the final step in the course of conservation, and that the idea should not be allowed to spread that conservation is the tying up of the natural resources of the government for indefinite withholding from use and the remission to remote generations to decide what ought to be done with these means of promoting present general human comfort and progress. For, if so, it is certain to arouse the greatest opposition to conservation as a cause, and if it were a correct expression of the purpose of conservationists it ought to arouse this opposition. Real conservation involves wise, non-wasteful use in the present generation with every possible means of preservation for succeeding generations; and though the problem to secure this end may be difficult, the burden is on the present generation promptly to solve it and not to run away from it as cowards, lest in the attempt to meet it we may make some mistake. As I have said elsewhere, the problem is how to save and how to utilize, how to conserve and still develop; for no sane person can contend that it is for the common good that nature's blessings should be stored only for unborn generations.

I beg of you, therefore, in your deliberations and in your informal discussions, when men come forward to suggest evils that the promotion of conservation is to remedy, that you invite them to point out the specific evils and the specific remedies; that you invite them to come down to details in order that their discussions may flow into channels that shall be useful rather than into periods that shall be eloquent and entertaining, without shedding real light on the subject. The people should be shown exactly what is needed in order that they make their representatives in congress and the state legislature do their intelligent bidding.

THE PALEONTOLOGIC RECORD

THE RELATION OF PALEOBOTANY TO PHYLOGENY

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THE history of plant life has been the central idea in all botanical studies from the very earliest times, whether expressed in the imperfect methods of the early German and Dutch botanists who desired simply to establish natural affinities on the basis of external resemblances, or in the ambitions of Cæsalpino to arrive at a classification of plants which should satisfy the conditions of relationship through the structure of all parts, and especially of the reproductive organs. For nearly four hundred years the external organs have been employed as the chief basis of those numerous systems of classification which have appeared from time to time. The idea that the reproductive organs and the minute interior structure of plants were of primary importance as first advocated by Cæsalpino, was for a long time lost to view, although it reappeared now and then in the works of later writers. Eventually it gained recognition and became a factor of increasing importance, until the most advanced systems are now employed involve an acceptance of both the external parts and the internal anatomy as essential factors.

From the time of Malpighi and Grew, to Goeppert and Corda, our knowledge of the interior structure of plants made great and rapid progress, and was later applied successfully by various investigators in the direction of establishing relationships. To no one are we more fully indebted for an elaboration of this idea than Williamson, whose researches into the structure of fossil plants from the Coal Measures of Great Britain, during the latter part of the last century, laid the real foundation of modern paleobotany.

In so brief a treatment as that which is now employed, it is impossible to more than touch upon some of the salient features in the relations of paleobotany to the course of phylogeny, but it is, nevertheless, worth while to give special emphasis to the now well-recognized fact that a thorough knowledge of the interior structure of the plant, and especially of the stem, leads to a more comprehensive and exact acquaintance with relationships than that of any other part. This arises from the fact that the minute anatomical details have a greater degree of stability than any other portion of the body, doubtless due to the fact that in its adjustment to the land habit, the environmental influences

present the least variable features in those factors which determine relations to mechanical stress and physiological needs.

External organs are notoriously subject to variation, even under slight alterations of surrounding conditions, within the limits of the species or even within various stages of development of the same individual. From this it is clear that organs such as leaves must be very unreliable for phylogenetic purposes. It is, unfortunately, true that much of the paleobotanical work based upon a study of such parts must be of inferior value, and the conclusions drawn will require extensive revision when the more rigid tests to be applied through a knowledge of the stem structure are brought to bear.

The value of paleobotanical evidence consists in its ultimate correlation with known types of plants, and it is obvious that all such studies should be prosecuted with direct reference to the broader requirements of plant biology. This involves a comprehensive knowledge of the history of plant life from its earliest development; that the data derived from a study of living species should be correlated with the evidence obtained from fossilized remains. Existing vegetation shows a very incomplete record of plant life as a whole. Its history as known until very recent times, and even now to a very large extent, is displayed only through the medium of detached groups, and relates chiefly to the most highly organized types. Through the perspective afforded by paleobotany, it becomes possible to not only supply missing facts, but to establish what theory has for so long a time required a satisfactory demonstration of—a more or less continuous series of phenomena from the rudimentary forms to the most advanced organisms.

Until a very recent date the Linnæan division of plant life into two great phyla, the cryptogams and the phanerogams, was the prevailing conception of the constitution of the plant kingdom. This division recognized no connection between the two great groups, but regarded them as wholly distinct in origin as in character. But the rapid advances in a knowledge of plant anatomy, developed toward the middle of the last century, and especially the remarkable and epoch-making observations of Hofmeister respecting the process of reproduction, enabled him to break down the old barriers erected by the doctrine of the constancy of species, and prove a genetic connection between the primary divisions of Linnæus. With this starting-point, the cryptogams and the phanerogams were subjected to a severe scrutiny from an entirely new point of view, with the result that each underwent a revision which led to such a rearrangement of subdivisions as to present an entirely fresh conception of their relations to one another. The logical result was finally expressed in the subdivision of the plant world into four great phyla, which, in their evolutional sequence, came to be known as I., Thallophyta; II., Bryophyta; III., Pteridophyta; IV., Spermatophyta.

Admirable as this scheme is, and scientifically acceptable as it has proved to be, it nevertheless presents certain well-recognized defects with respect to the requirements of theory, although at the time of its formulation and as late as 1899 it represented the sum of available knowledge. It was just at this time that paleobotany became available as a means of meeting those deficiencies which a knowledge of living plants could not overcome. For a long time botanists have been familiar with certain Paleozoic remains having a fern-like aspect which were generally accepted as ferns; but because of their want of direct connection with stems or fruit, there remained a serious doubt as to their real character. In the same horizons, detached fragments of stems were also observed with increasing frequency. The study of their anatomy disclosed a structure which, in some respects, was curiously like that of ferns, while in other respects it approximated to the anatomy of the higher plants as presented in some of the gymnosperms. This combination of filicinean and cycadean characters was noted by Potonié, who succeeded in correlating them and expressing their phylogenetic position in the name of a new order which he called the Cycadofilices.

There yet remained to be considered certain remarkable fruits for which no relationship has as yet been determined until, through the work of Scott, Oliver, Kidston and others, it was shown that they were of the nature of seed-bearing organs which could be correlated with the Cycadofilices. It thus became evident that there was a hitherto unknown group of plants combining the characters of ferns in their foliage and stem structure with those of primitive gymnosperms as presented in their stems and fruits. On the whole, however, these plants approached most nearly to the pteridophytes in their external features. To this new phylum, of which the Cycadofilices formed the most conspicuous member, Scott and Oliver in 1904 assigned the most appropriate name, Pteridospermæ. This result was based entirely upon paleontological evidence through comparative anatomy, and it compels us to recognize the existence of five, instead of four great phyla. The far-reaching significance of this achievement can not be overestimated. It is not only of the utmost importance as proving the general course of evolution and bringing into the realm of proved facts what had previously been a working hypothesis only, but it offers an entirely new point of departure for the botanist of the future. Attention may also be directed to one other effect. The tendency of this discovery is to coordinate, unify and strengthen all branches of botanical knowledge, bringing to us the conviction that the more extended and thorough our knowledge of the earlier forms of vegetation becomes, the more satisfactory will be our knowledge of the science as a whole; for while the example selected is probably the most important for our special purposes, the general utility of paleontological research in relation to the

history of development is enforced upon our consideration in a great many subordinate ways.

Recognizable plant remains first occur in the Silurian in the form of certain highly organized algæ, the ancestral forms of which are unknown. Nevertheless, the history of *Nematophycus* shows that in the Silurian and extending through the Devonian, members of the brown algæ directly comparable with the modern kelps, both in general character and in detailed structure, had attained to a development unknown to any of the marine algæ of to-day. Arborescent forms with stems two feet in diameter and a corresponding height lead to the inference that they not only represent the culmination of the phylum at that time, but that they must have been preceded by a long line of ancestral forms, extending far back into the earlier horizons, possibly into the Eozoic itself.

Parka decipiens from the old Red Sandstone of Scotland affords striking illustration of the very early period at which heterospory was developed among vascular plants, which, according to the evidence now available, are comparable with the genus *Marsilea* among existing types. In these remains we meet with prostrate stems often one to two inches in diameter, from which slender, upright branches are produced, bearing in turn conceptacles containing both micro- and mega-sporangia. Some of these latter further contain prothalli in various stages of development.

The earliest form of gymnosperm is that which we recognize in the genus *Cordaites* from the Devonian. The highly developed and dicotyledonous character of the stem affords abundant evidence that the ancestral type must be looked for in some remote and earlier horizon, but, taken as an isolated case, it affords no clue whatever to the origin of that particular phylum, although the subsequent course of development may be traced with considerable certainty to comparatively recent times.

The obvious conclusion to be drawn from the geological relations presented by such illustrations as those recited, is, that the evolution of even very simple forms from the most primitive plants must have called for enormously lengthy periods of time. Even the most liberal application of the law of mutation would fail to adequately account for the extensive gaps which are recognized as occurring between the simpler types and those which lie in the same general line of succession, but with greatly advanced organization.

We are now led to ask, how far have paleontological studies carried us in our knowledge of plant life from the earliest times, that is, do they enable us to trace an unbroken series of steps from the first to the last? To this the answer must be that, while paleobotany has been of the greatest service in supplying missing data, in filling great gaps in a supposed sequence and in giving the fullest support to the law of evo-

lution, it is as yet by no means adequate with respect to meeting all that theory demands. For this there is an intelligible explanation based in part upon the fact that the necessary material is available only under conditions of great difficulty; and that the character of the remains upon which research is based is conditioned by the original nature of the structure and its ability to survive in an unaltered form, the remarkable conditions of decay, infiltration, compression, upheaval and often of volcanic influences to which it has been subjected. The earliest type of vegetation was that which we now find in hot springs, continued with the algæ found in cool or cold waters, all of which possessed a delicacy of structure which permitted speedy decay. The great abundance of such organisms probably afford an adequate explanation of the Laurentian and later forms of graphite which is regarded by many as the remains of former vegetation. While this hypothesis may be accepted provisionally, paleobotany is nevertheless wholly unable to furnish any clue to the life history of the individuals, or even to inform us as to the specific types. Such knowledge as we possess in this direction is the result of inference from parallel conditions and structures as now found.

It might be assumed that with an increasing perfection in the preservation of fossil remains, as found especially in the later formations, it should be possible to trace the course of descent with accuracy and completeness. This is, in a measure, true, but although the general requirements of theory may be verified, yet the haphazard conditions involved in the collection of plant remains make it a very difficult matter to secure a complete narrative, and there remain many gaps which it is difficult to fill. The evolutional position of the Bryophytes demands that the origin of these plants should lie somewhere in the early Silurian or even in the Eozoic age, but we have no certain knowledge of them until the middle Mesozoic, and their remains do not become familiar or abundant until the later Tertiary. So important a deviation from what theory demands should lead us to caution in drawing conclusions from the direct testimony which is thus presented. Unless otherwise disposed of through paleontological evidence, it would be more correct to infer that the delicacy of the plants, and the conditions of their fossilization, have not admitted of their preservation in a recognizable condition; while there is also the further probability that many of their remains have been overlooked through resemblance to certain Pteridophyta for which they might well be mistaken.

In spite of such apparent contradictions, the evidence everywhere points with great force to the idea that each of the lesser phyla had its origin in some ancestral form, followed by growth and culmination. This latter was, in some cases, abrupt, as in many of the Pteridophytes; in other instances there was a gradual decline, as in the lycopods or the horsetails, which attained their highest development in the later Paleo-

zoic, but have since been in a state of degeneracy, their present representatives being few in number and of a depauperate character. The application of this law throughout the enormously lengthy periods required for the evolution of existing species, has led to the survival of some of the most ancient types until the present day; to the absolute obliteration of others which at one time gained great prominence; and to the gradual dying out of yet others, some of which are now found in the last stages of their existence. But through the entire course of change, the evolution of higher and yet higher forms has been the most conspicuous fact. Furthermore, it is undoubtedly true that the general course of evolution is in progress to-day as in the past, since all the potentialities of such evolution exist now as always, though conditioned by the fact that owing to continued changes in the physical character of the earth's atmosphere as well as of its crust, the possibilities of evolution are steadily diminishing and will eventually cease.

There is one direction in which paleobotany gives well-defined assurance that the evidence derived from existing species leads to correct conclusions. In tracing the succession of types, we are led to the belief that there is no direct sequence. Conterminous evolution is in accord with neither theory nor ascertained facts, and it is, therefore, impossible to conceive of a figure which shall in any way represent a single and unbroken line of succession. If paleontology teaches us anything, it is that each great phylum, as well as its various subdivisions, finally reaches its culmination in a terminal member from which no further evolution is possible. But that from some inferior member, possessing high potentialities, a side line of development arises. There is thus, in the early life of each member of the series, a certain recapitulation of ancestral characters. This conception of a continuance of the main line of descent through a succession of lateral members is both logical and fully in accord with the evidence derived from both recent and extinct forms of plant life, as well as with our present theory of evolution.

PALEONTOLOGY AND ISOLATION

By Dr. JOHN M. CLARKE

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THE notion of isolation as a factor in variation, as I am using the term, is that of geographic separation exclusively, the conception expressed most clearly by Wallace, Moritz Wagner and Jordan. I take it that while this influence has been carefully estimated in the geographical distribution of living species, it has not often been expressed in its own terms in the analysis of extinct faunas. With increasing accuracy in the record of ancient continental lines and bar-

riers, we are coming to a point where the efficiency of this factor can be safely taken into account. The outcome of free interbreeding, as Jordan has pointed out, is to unify species and obliterate variations. *Per contra,* isolation checks this process and gives freer play to tendencies arising from other factors in variation. The effect is thus, as a general rule, negative, but expresses itself freely enough in geographic provinces severed by some barrier or condition which has the effect of a barrier. Among existing species the formative effects of segregation have been very largely illustrated from restricted areas such as the subdivisional valleys and forests of Hawaii with its distinctive forms of the Helicidæ and other terrestrial snails—a case that is paralleled in paleontology by the snails of Steinheim. But the effect is to be reckoned with in larger or continental areas between which there has been at one time opportunity of interchange, especially in the case of marine species, with which we chiefly deal, along the epicontinents.

I have particularly in mind phenomena which have been brought to my notice by a somewhat extended study of the Devonian faunas of the southern hemisphere and the broader application of the factor is best enforced and illustrated by this instance. I may say that this broader notion seems to be that entertained by Darwin so far as he specified the conception of geographic segregation as an element in natural selection and it was his work in South America that formed the basis of his conclusions.

With other students we recognize the existence during the Devonian of austral continental lands which have been variously designated and variously outlined. By some this land has been posited as a north and south Atlantis lying in the meridional axis of the present ocean, by others a broken land mass partly crossing the southern Atlantic from east to west. But now we begin to see its continuity and the extent of its strands, with something of its changes in outline during its early history. It was the precursor and the nucleus of Gondwánaland. With it began, so far as we now know, the long history of that continental land and the successive records of life developing under continued conditions of geographic isolation from the northern strands.

From Argentina, Bolivia and northern Brazil we have very lucid evidence, on the basis of paleontology, that in the late Silurian the shore lines were continuous with those of the north. We have no dependable knowledge of these earlier faunas at the east and indeed their entire absence is indicated by stratigraphy; but with the submergence of the Silurian at the west, there entered from the African east upon this south Atlantic field, a positive diastrophism whose axis was well nigh normal to that of the present Atlantis, and along the shores of this growing land bridge entered an invasion of marine life

at the opening of the Devonian time. It seems to have come westward from a dispersion area in Africa and it evidently disseminated itself without interruption of continuity from the strands which now, as the Bokkeveld beds of Cape Colony, constitute the only evidence of marine life in the South African Paleozoic, to those of the Falkland Islands, two far distant regions which have much more of organic content in common than do the Falklands and the nearer regions of Paraná, Argentina and Bolivia.

This fauna with its special and peculiar features is, however, spread through Bolivia, western Argentina, southern Brazil, including Paraná and as far north as Matto Grosso, thence eastward by way of the Falklands to South Africa. From the boreal strands of the period it was separated by a barrier, often narrow and constituted only of deeper water, so that of the boreal Devonian we find no evidence much south of the equator in Brazil nor of the austral Devonian north of that line. This barrier I believe to have been overpassed at times during the early part of the Devonian by species which are of wider distribution south and north but these passages seem to have become rarer as time passed and as more complete geographic isolation was effected.

There are many evidences in this southern fauna that the land bridge was accompanied by insular strands which are evidenced by varying percentages in community of species and by bathymetrical variations. Apart from these possible island masses, there was clearly a Devonian land bridge extending from South Africa to the Falklands, westward into Argentina and northward into Bolivia, embracing also as continental or island lands parts of the states of Paraná, Matto Grosso and even of Pará.

By virtue of the evident derivation of the fauna of this time from the east along newly forming strands which were, throughout the period of the Devonian, kept asunder from the Atlantic-European lands at the north, and by its further development under conditions of isolation, the fauna presents fundamental contrasts to any development of the Devonian elsewhere in the world. It is in itself a unit and a unit also in relation to the sediments in which it is involved. There is no earlier Devonian in this southern region nor is there any later Devonian, for wherever the succession has been determined this austral fauna, bearing no evidence in itself of a later time stamp than early Devonian, is overlain by Carboniferous deposits without demonstrated unconformities between. Deposits and faunas which at the north we are accustomed to regard as of later Devonian age, are absent at the south, either because this austral land was broadly above the sea during these stages and its strands now lie buried or, as seems much more probable, this sedimentation represents the total Devonian sedimentation and this fauna the total Devonian fauna at the south.

I can not in this place analyze the peculiarities which give the austral fauna of these "Falklandia" strands their special impress but I may specially cite the trilobites which are astonishingly developed. I presume any competent student of northern faunas, being shown a series of these without knowledge of their origin, would pronounce them of early Devonian age and yet they are neither northern species nor, in any large degree, northern genera. While they bear the impress of boreal genera and resort to morphologic equivalencies thereto in fugitive epidermal structures which so richly characterize the boreal trilobites at this time, they are on the whole constructed on a series of modified types which hold their fundamental expression while developing minor details with the chronology normal to their succession at the north. The *Phacopes* are seldom true *Phacopes,* the *Dalmanites* seldom true *Dalmanites,* yet the same structural decorations and extravagances we are familiar with at the north, are distributed freely through the group. This is all equally true, in qualifying terms, of the other groups of this fauna, save for the fact that in these we can hardly venture to insist so entirely on generic distinctions south and north. The species differences declare themselves on every hand and taken as a whole the fauna presents fairly conclusive evidence of having derived its distinctiveness through its isolation from the boreal fauna from which it ancestrally took origin. Yet while it has developed this character it has also proceeded to maintain a faunal composition which declares its age, and a morphological stamp which shows that it developed all its parts in the proper time and place in the series.

In predicating geographic isolation as the prime factor in this regional development of the Devonian fauna, its efficiency should not be made to seem qualified by an illustration which is striking by virtue of its contrast with the already well known. There are evidences in plenty that geographic isolation has played a similar rôle with even more diverse effect in the development of the boreal faunas of the same geologic stage. The north Atlantic land bridge was continuous at this time, as evidenced not alone by the presence of the Coblentzian fauna in the Atlantic coast rocks but by an array of additional facts; and it seems very probable that the primary movement of these northern faunas was from the same African dispersion area as that of the south.

THE RÔLE OF HYBRIDIZATION IN PLANT BREEDING[1]

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THE word hybridization has been used with many meanings. The term is used here to denote the crossing of any two plants that differ from each other in a heritable character, whether they are of the same or of different species.

There is intimate connection between the rôle of hybridization and the rôle played by selection. It comes about in this way. Inherited variations are produced by nature with considerable profusion. New characters appear and old characters are lost: these form the working basis of selection. But whether they are large or small they are usually inherited completely. They are the units of heredity; or, if they are sometimes transmitted in units of lesser degree, they may be compared to chemical radicals.

The main object of hybridization then is the shuffling of these units in the first hybrid generation and their recombination in the next generation. There are, however, various phenomena attending hybridization, and I will endeavor to illustrate the following as those of most importance: (*a*) Recombination of characters and their fixation, (*b*) production of desirable combinations in the first hybrid generation and their continuation by asexual propagation, (*c*) production of fixed first generation hybrids, (*d*) production of blends.

If we begin at the real beginning in this discussion, we must say a few words concerning the actual mechanical operations of crossing. The first foundation stone to be laid is a knowledge of the flowering habits and flower structure of the plants to be used. Of course a careful examination of the flowers will show the easiest and surest method of removing the stamens of the flowers that are to be pollinated and of protecting them from foreign pollen. What is not so easily determined are the precise conditions under which the cross should be made to be successful. The proper preparation of the breeding plot even before the plants are grown is necessary. One takes it for granted that some fertilizer will be used, for the plants must be normal to seed well. The three essential elements of soil fertility are nitrogen, potassium and phosphorus, and to get the best results compounds of these elements must be present in proper proportions. First, available potash must be

[1] This paper is based on one of a series of popular lectures delivered at the Bussey Institution of Harvard University, April and May, 1910.

present in normal quantity although a certain excess will not be harmful. If nitrates are present in excess, however, vegetative growth will be over stimulated and seed production will be small. A lack of phosphates will produce the same effect upon seed production, but for a different reason. Phosphorus is an essential constituent of the proteid compounds found in large quantities in the seed. Therefore, if the plants are to be in the best condition for crossing, the soil should contain just the right amount of nitrates for normal growth and a generous supply of potash and phosphates. The exact amounts must be determined by experience for each soil and each species of plant.

Other necessary knowledge that can be obtained only from experience is which are the best flowers on the plant to serve as parents of the cross and what is the proper time for their pollination. For example, in the grasses the first flowers that appear usually form larger, healthier seed than the later blossoms. In most of the Solanaceæ, the petunias, browallias, etc., the exact opposite is true. The time when the individual flower is most receptive to pollen is even more narrowly limited. Both premature and delayed pollination is the cause of many failures and the optimum time should be accurately determined. Having exercised these precautions, it remains to study carefully the structure of the flower in order that it may be emasculated—*i. e.,* the anthers removed before the pollen is shed—with sufficient adroitness that neither the anthers shall be opened nor the parts of the pistil injured. Only a few buds upon a single flower spike should be operated upon if they are to be given the best chance of development. If the buds are very small and some pollen unavoidably reaches them, it may be washed off with comparative safety with a dental syringe if done immediately. It is often recommended that the calyx and corolla be cut away when emasculating. This should be avoided if possible and the floral envelopes left as a protection to the pistil. After emasculation the buds should be protected from foreign pollen until time for pollination, and again after pollination at least until the fruits have begun to form. This protection may be an ordinary paper bag when the crossing is done in the field. In the greenhouse I find that a square of thin celluloid rolled around the flower and caught with two rubber bands, each end being protected with absorbent cotton plugs, is a better device. It gives excellent protection and allows transpiration.

But enough of the technique of hybridizing; the phenomena attending it are of more importance. After the pollen is placed upon the stigma it begins to grow until it reaches the ovule. Down this tube comes the male cell which contains the potentialities of its parent plant. This cell fuses with the female cell in the ovule and fertilization is accomplished. From this combination the seed and later the hybrid plant results, half of its characters coming from the plant which fur-

nished the pollen and half from the plant to which it has been applied. If one studies the characters of several such hybrids, he finds many surprising facts. It usually makes no difference which plant is the mother plant, the result is the same. Certain characters are found in the hybrid that are identical with those possessed by the male parent and other characters the same as those possessed by the female parent. Other characters appear to have resulted from the blending of those of the two parents, while still others appear to be entirely new. The plant may be sterile if the cross is between widely differing species, but if it is fertile and the flower of the hybrid is self-fertilized, the plants resulting from this seed present still more surprises. For example, if one has crossed a pear-shaped yellow tomato with a round red tomato, in the second hybrid generation he will find individual plants bearing fruit of four kinds, pear-shaped yellow and round red, as were the two parents, and in addition pear-shaped red and round yellow. In other words all possible combinations occur and in definite proportions. Stated as a principle it may be said that where either of the parent plants possesses characters absent from the other, the potential characters remain pure in the germ cells of the hybrid and recombine as if by chance. This is the most important feature of the only law of heredity of which there is any exact knowledge—the law of Mendel. Let us illustrate the action of the law. Such a character as starchiness, as shown in "flint" maize, is either present or it is not present. The flinty appearance of the seed is due to the possession of some character that causes the maturation of plump starch grains. When this character is absent, the seeds dry up without maturing their starch grains, and present the wrinkled appearance common to sweet maize. Pairs of characters such as these, affecting a certain plant structure, are called contrasted or allelomorphic pairs. When a sweet maize is crossed with a flint maize, the resulting seeds are all flint like. That is, the dominant character or the character that calls for the presence of the structure or compound in question, manifests itself in the first hybrid generation. Complete dominance, however, is not a general phenomenon in crosses and as its importance is slight as compared with the second law, that of segregation of the pure characters (potentially) in the germ cells of the hybrid, we will discuss it no further. The second law predicts that in the generations succeeding a cross, plants grown from the self-fertilized seeds of the hybrid reproduce both contrasted characters in the proportion of three of the dominant or "presence" characters to one of the recessive or absent character. Furthermore, inbred or self-fertilized plants bearing the recessive character continue ever after to breed true, while of those plants bearing the dominant character one third are pure and breed true while two thirds are hybrids and again throw the recessive character in one fourth of their offspring.

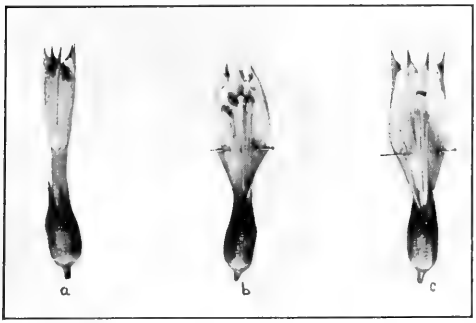

FIG. 1. CASTRATION OF BUDS OF *Nicotiana tabacum* BEFORE CROSSING. *a*, correct stage for castration; *b*, method of slitting the corolla; *c*, castrated bud.

The theory supposes that when a dominant and a recessive character meet in a cross, the germ cells which are produced in the hybrid do not blend these characters, but possess either the one or the other; and as the possession of either character is a matter of chance, on the average 50 per cent. will bear the dominant and 50 per cent. will bear the recessive character. In a plant, for example, 50 per cent. of the pollen cells would bear the dominant and the other 50 per cent. would

FIG. 2. CASTRATED BUD OF *Impatiens sultani* SHOWING METHOD OF PROTECTION IN GREENHOUSE WORK.

bear the recessive character. One half of the egg cells, likewise, contain the dominant, and one half the recessive character.

Now, if we could pick out at random any one hundred pollen or male cells to fertilize any one hundred egg or female cells, we can see that there are equal chances for four results. A dominant male cell might meet a dominant female cell, a dominant male cell a recessive female cell, a recessive male cell a dominant female cell, and a recessive male cell a recessive female cell.

We have (D + D), (D + R), (R + D), and (R + R) plants formed in equal quantities, but as the two middle terms are the same, we can reduce the formula to one (D + D) to two (D + R) to one (R + R). But wherever there is a D present in the germ cell, the

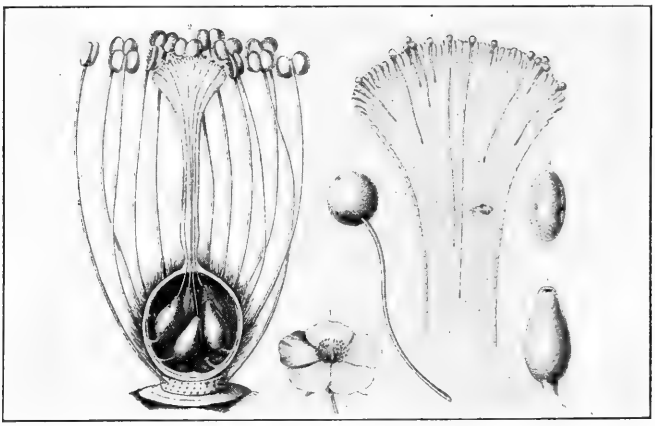

FIG. 3. THE COURSE OF THE POLLEN-TUBE IN A ROCK-ROSE (*Helianthemum marifolium*). After Kerner and Oliver. 1, single flower; 2, essential organs of flower: course of pollen tubes shown diagrammatically; 3, pollen tubes penetrating the tissue of the pistil; 4, dried pollen grain; 5, pollen grain germinating; 6, ovule.

dominant character shows, while the recessive character is hidden. The one part or 25 per cent. of the individuals showing the character (D + D) will appear just like the two parts or 50 per cent. of the individuals having the character (D + R). Therefore, there will be 75 per cent. of the individuals which will show the dominant or D character, while 25 per cent. will show the recessive or R character. These 25 per cent. showing the R character will ever after breed true, because they contain nothing but the recessive character; while of the 75 per cent. showing the dominant character, one third or those having the pure (D + D) character will breed true in succeeding generations, while the other two thirds having the (D + R) or hybrid character will again split in the next generation.

For all practical purposes in plant breeding the mere fact of segregation is of greatest importance and the complexity of recent Mendelian

interpretations need not bother us. Suffice it to say that most plant breeders have accepted the explanation that the recessive character is simply the lack or absence of the character in question, while the dominant character is its presence. This is simply a slightly different interpretation of the same facts and simplifies some of the more complex results of crossing. Instead of 50 per cent. of the germ cells bearing the flint character and 50 per cent. bearing the sweet character when sweet corn is crossed with flint corn, one should think of all of the germ cells bearing the ability to produce the wrinkled sweet corn seeds, but that 50 per cent. of them contain in addition the presence of a flint or starch producing character. In other words, the "starchy" character is superimposed upon the "sweet" character. The dominant and recessive characters in such a cross, then, are simply the presence and absence of the starchy character.

When several character pairs differentiate the two parent plants in a cross, all possible recombinations are formed, the relative frequency with which the combinations occur being simply the algebraic product of as many of the simple ratios as there are character pairs.

The importance of these Mendelian facts to the commercial plant breeder is great. In crossing plants differing in several simple characters that segregate after hybridization he may rest assured of two things. First, that with a sufficient number of progeny in the second hybrid generation, every possible recombination of the characters present will be represented by at least one *pure* specimen. Second, that these pure specimens when selfed, or pollinated with their own pollen, will breed true. It should be remembered, however, that one may have to self a number of plants to get the combination desired with all characters pure, for if any dominant characters are concerned, their purity can be ascertained only by breeding for another generation. As an illustration we may take the snap dragon, Antirrhinum. There is a long series of colors that segregate. There is also a type called the "Delilah," where the tube of the corolla is uncolored. Starting with this form in only one color, the whole color series of Delilah forms may be reproduced by crossing with the self colored strains. Or, one may combine the dwarf habit of growth of the Dwarf Champion tomato, with any of the various colors and shapes now on the market which have the ordinary tall habit of growth. Sometimes a very simple recombination is of very great commercial value. The so-called Havana type of wrapper tobacco grown in the Connecticut River valley has large leaves and a short stocky habit of growth. It produces from nineteen to twenty-one leaves. There is another type grown under cheese cloth shade which has a tall habit of growth with about twenty-six smaller leaves. The tall slender habit of growth makes it an undesirable type to grow in open fields where it is apt to be blown down. Mr.

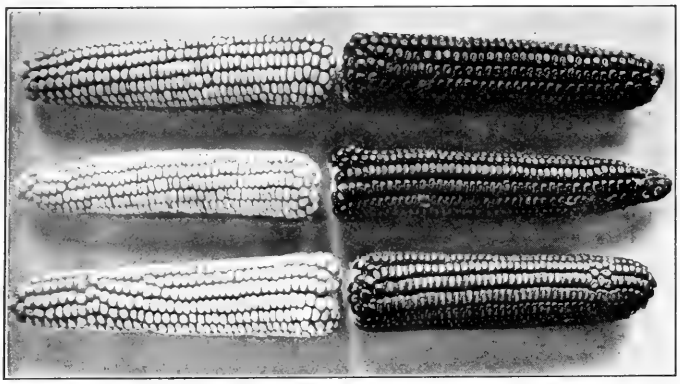

FIG. 4. SHOWING ABSOLUTE SEGREGATION IN SECOND HYBRID GENERATION. These red and white ears grew from a single self-pollinated ear of the first hybrid generation of a cross between red and white maize.

A. D. Shamel, of the United States Department of Agriculture, crossed these two types. A new type called the Halladay has been produced with the higher number of leaves of the Cuban parent and the stocky habit of growth and large leaves of the Havana parent. The first interpretation of this result was that an entirely new variation had appeared, for the Cuban type usually has but twenty-two or twenty-three leaves. The writer has been able to show, however, that the actual strain of the Cuban used as the parent of the cross has on the average twenty-six leaves, and data have now been collected that show that the new variety is a simple recombination of the characters possessed by the two parents giving an out-door type averaging thirty per cent. greater yield than the old Havana strain. In a similar way Biffen has produced a rust resistant high-yielding wheat by crossing two varieties each of which possessed but one of these desirable qualities. Orton has combined the edible quality of the watermelon with the wilt resistance of the citron, and Webber has increased the ability of the orange to resist cold by crossing with the hardy trifoliate orange.

Recent accurately controlled investigations in hybridization have shown that many apparently complex results yield to simple explana-

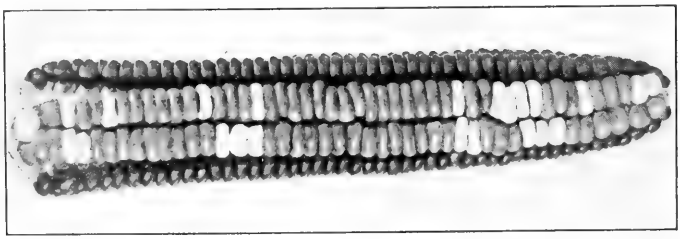

FIG. 5. RED MAIZE EAR WITH PERICARP REMOVED, showing segregation of yellow and white endosperm beneath it.

tions by use of the Mendelian theory. For example, two or more hereditary factors may be necessary for the production of an actual tangible character. If factors A and B must be present for its production, then a plant carrying only factor A and another carrying only

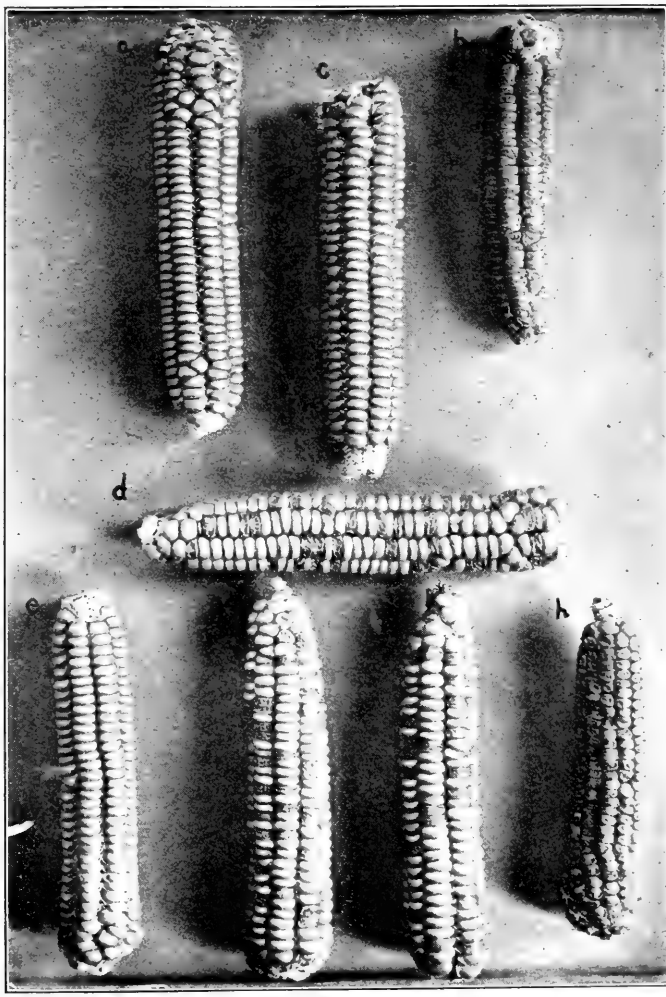

FIG. 6. MENDELIAN SEGREGATION IN MAIZE. *a* and *b*, the two parents, starchy and sweet maize; *c*, the first hybrid generation showing dominance of starchiness; *d*, the second hybrid generation showing segregation with the ratio of three starchy to one wrinkled seed. Lower row daughters of *d*. *e*, *f* and *g*, results of planting starchy seeds. One ear out of three is pure starchy. *h*, result of planting sweet seeds. Ear is pure sweet.

factor B do not possess the character. But let the two plants be crossed and the character appears. There are two white varieties of sweet peas; each, however, contains one of the two factors necessary for the pro-

FIG. 7. AT LEFT "HAVANA" PARENT, AT RIGHT "CUBAN" PARENT OF CROSS SHOWN IN FIG. 8. The "Havana" has short habit of growth, large leaves averaging 19 to 21 in number. The "Cuban" has tall habit of growth and averages 26 medium-sized leaves.

duction of a purple variety. When these two white varieties are crossed, the purple variety results. The second generation, however, produces seven whites to every nine purples. Such segregation into purples and whites may not be desirable; all purples may be wanted. This brings us to a consideration of class B of the four classes of phenomena attending hybridization, the production of desirable character combinations in the first hybrid generation and their continuation by asexual propagation. This class really includes several distinct types of occurrences. The purple sweet pea produced from the two whites will serve as an illustration of the first type. In certain plants (not meaning the sweet pea, however) it is as simple to reproduce by cuttings as by seed. The cuttings are simply parts of the plant from which they come and are identical with it in character.[2] If in a species of this kind a desirable character is formed by the union of two or more hereditary factors and one wishes to reproduce the character indefinitely, asexual reproduction by cutting serves the purpose admirably.

[2] There are certain cases like variegation that are exceptions to this rule.

There is another case of a different kind. Sometimes the hybrid character is different from the character of the parents, even though the exact parental characters are reproduced by segregation in succeeding generations. The commercial carnation form is the result of crossing the single carnation with the huge worthless doubles called "busters." Reproduced by seed the commercial carnation throws both singles and busters, showing that segregation of the parental characters takes place; but as these plants are easily reproduced by cuttings, and the cuttings are all of the commercial type, sexual reproduction is only resorted to for the sake of producing new varieties. Another common phenomenon attending hybridization is sterility. Many very beautiful flowers produce no seed at all. This is even an advantage in some cases, because the plants flower more profusely than if they were spending their energies in the production of seed. Here again, cuttings are resorted to to reproduce the hybrid, or, as in the case of seedless oranges, the cuttings are grafted into an older rootstock instead of being rooted.

I stated at the beginning that there were two other classes of hybridization phenomena, the production of fixed first-generation hybrids and the production of blend hybrids. It is probable in the last analysis that the true explanation of these cases is the same; so we will consider them together. It is believed by many that there are kinds of inheritance other than Mendelian, that is, inheritance where no segregation occurs. Far be it from me to deny this; *I simply state the fact that there are no exact data extant proving other kinds of inheritance.* Such data may be found, but it is useless to speculate upon other laws without such evidence. There are several cases in which either new characters that breed true or blended characters that breed true *appear* to have been formed, but they have not been studied with sufficient care for an analysis of their mode of inheritance to be accurate and final. It is in crosses between true species that hybrids have been formed seemingly as constant and uniform as their parent species. Janczewsky has produced several such hybrids. Perhaps the most famous, however, are the blackberry-raspberry crosses first produced by the late E. S. Carman, editor of the *Rural New-Yorker* and later by Luther Burbank and others. Several hybrids having a commercial value have been made in this genus (*Rubus*), and all of them reproduce approximately true from seed. These are the facts and show what may sometimes be expected by hybridizers when crossing true species; but I wish to point out that this does not necessarily mean that we are dealing with a new mode of inheritance. Bramble species produce seedlings that are quite variable and in which the variations are extremely difficult to describe; there is, therefore, no exact information as to the relative variability of the hybrid seedlings as compared to that of the two parents. It may be said, then, that it is yet unknown whether there is partial segregation.

FIG. 8. FIRST HYBRID GENERATION OF CROSS BETWEEN "HAVANA" AND "CUBAN" VARIETIES OF TOBACCO SHOWN IN FIG. 7. Plant is taller than either parent showing the increased vigor due to a cross. Size of leaf of "Havana" is dominant. Habit of growth of "Cuban" is dominant. Number of leaves is intermediate, but approaches the "Cuban."

But why should there not be complete segregation to the types of each parent? In the first place, because it is likely that numerous separately heritable characters are concerned, and when n pairs of characters are concerned it takes four to the nth power seedlings to run an even chance that there will be one plant like each of the parents. When we consider that with ten pairs of characters, this means over 1,000,000 individuals, we can see with what enormous numbers one has to deal. In the second place these hybrids are only partially fertile, and as I have suggested in former papers, some consideration must be given the fact that there may be selective fertilization that works against ex-

FIG. 9. RECOMBINATION OF CHARACTERS OF PLANTS SHOWN IN FIG. 7, occurring in the second hybrid generation. This is a uniform and constant type having the short habit of growth and large leaves of the "Havana" parent, combined with the high number of leaves of the "Cuban" parent. It is now grown in the Connecticut River valley and yields 40 per cent. more than the Havana type.

treme segregation. To take a hypothetical case, suppose two plants are crossed in which the flowers of one are twice as long as the flowers of the other and that this extra length is controlled by three or four separately heritable factors. If only a few of the egg cells can be fertilized on account of dissimilarity from the pollen cells, one would expect only those seeds to be formed that would come from the fusion of the germ cells nearest alike. Intermediates would therefore be more likely to be formed than extremes. There is one other possible way of accounting

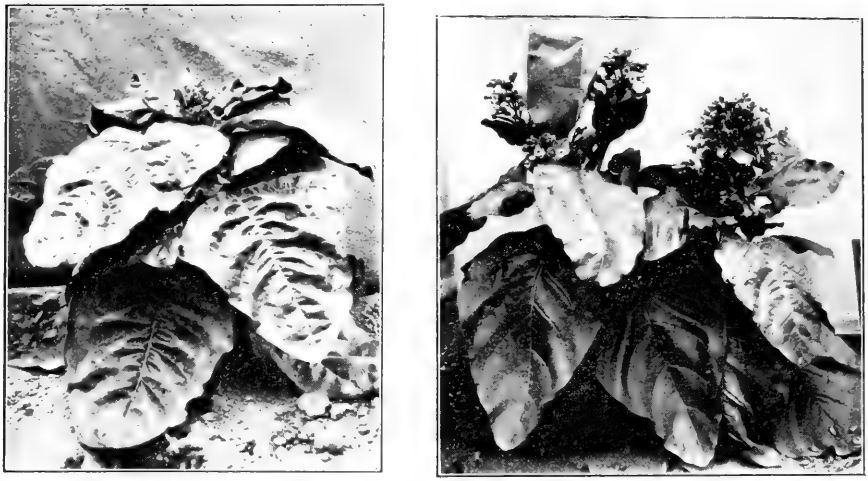

FIG. 10. SEGREGATION OF SIZE CHARACTERS. At left *Nicotiana rustica brazilia.* This plant was crossed with *N. rustica scabra* shown at left in Fig. 11. At right is a segregate of the second hybrid generation which is exactly like its parent. Unfortunately it has branched at the base or the similarity would be more striking.

FIG. 11. SEGREGATION IN SIZE CHARACTERS. At left *Nicotiana rustica scabra.* This plant was crossed with *N. rustica brazilia* shown at left in Fig. 10. At right is a segregate of the second hybrid generation exactly like its parent in size of plant, leaf and flower and in habit of growth.

for constant intermediate hybrid races which I think has never before been mentioned. In crossing species of the genus Nicotiana, I have had plants develop from seed that have apparently been formed apogamously, that is, formed from an immature egg cell without fertilization. It is evident that this is induced by the extraordinary irritation of foreign pollen. The true hybrid plants that are formed are generally blends in the first generation. The question, then, arises: May not the difficulty of maturing sexual cells in a wide cross sometimes cause apogamous development and therefore a continued propagation of a constant and uniform race?

All but the last of these suggestions may also be pertinent in the case of varietal crosses where there is said to be a blending of characters that deal with size. I am not certain, however, that all the so-called blend hybrids might not show segregation if studied in large numbers. I have found such segregation in size characters in crosses of both maize varieties and of tobacco varieties.[3]

[3] In the writer's paper "The Rôle of Selection in Plant Breeding" in the August number of this journal, the legends for figures three and four unfortunately were interchanged in printing.

THE NATURAL HISTORY AND PHYSIOLOGY OF HIBERNATION

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Introduction—Natural History

IN this most important and interesting phenomenon of nature—a truly protective phase—let us first briefly consider the natural-history side of the subject, describing how hibernation is peculiar to, and differs, in the various animals possessing this function of protective winter sleep. Then we will consider the various physiological phenomena characteristic of this torpid state. Let us first make clear the meaning of some of the terms used in connection with this condition.

The term "hibernation" is used by scientists and naturalists to signify the peculiar somnolent or torpid state in which many animals, both warm- and cold-blooded, inhabiting cold and temperate climes, pass the winter. On the other hand, in hot and dry countries, various animals pass into a similar condition during the hottest and dryest season of the year, and this state is called "æstivation."

Many of the animals which hibernate during the winter are liable to fall into a similar state at intervals during milder seasons—Dr. Marshall Hall considers the day sleep of bats as a species of hibernation and has called it "diurnation."

In man it is a question if true hibernation ever occurs—a similar condition may exist, however, but it is very rare either for a prolonged or short period. Cases of hibernation (?) in man are most frequently found in India, where some religious ascetics are stated, upon unimpeachable authority to possess the power of throwing themselves into a state closely resembling hibernation (trance?) for an indefinite period. Many curious cases have been recorded by Mr. Braid in his treatise on "Human Hibernation"; the most celebrated and best known is that of a "fakir," who, in the presence of Sir Claude Wade, the English governor, was buried alive at Lahore in 1837, was exhumed and restored to consciousness after remaining in the ground for several months, the grave being guarded and every precaution taken, in the meantime, to prevent any interference or disturbance of the body.

One of the largest groups of hibernating animals we have is that of bats—Dr. Marshall Hall claims that the bat when hibernating, practically never wakes, but when disturbed will breathe naturally,[1] for a few minutes, but will then return to its former state of quiescence.

[1] *I. e.*, as in a fully wakened state, quicker and deeper.

Earlier or later in the autumn, according to the species, the bats retire to caves and hollow trees and similar places, where they cluster together, hanging by their hind claws, head downward, and clinging to one another as well as to the walls of their retreat. Such masses may comprise various species, yet all species do not retire at the same time.

The noctule is seldom seen abroad later than July—while the pipistrelle may be seen flying any warm evening during the spring, summer and autumn months.[2]

Owing to the difference in the flying season of these different bats, it is only natural to suppose that the hibernation of the former species (noctule) is much deeper and longer than in the latter (pipistrelle), which may feed all the year round. Here in North America some bats may, and probably do, migrate southward to avoid the too intense cold, and among these is probably the noctule, which is the first to come and the first to go.[3] These "flitter mice"[4] are insectivorous, and before discussing some of the other mammalia, it may be advisable to call attention to some points of difference existing, during the hibernating state, between the carnivorous and herbivorous animals.

Bears come out of the hibernating condition as fat, or nearly so, as when they retired in the fall; marmots, ground squirrels, etc., emerge in poor condition, in some cases quite emaciated; this in spite of the fact that they are functionally torpid, while bears and skunks are not. Female bears even bring forth their young while hibernating and suckle them from about the beginning of February to April, while they obtain no nourishment themselves.

The bear and badger, in our northern and western climates, retire to their winter quarters and pass the greater part of their time in sleep, yet neither the brown bear[5] nor the badger falls into a true state of hibernation. On the other hand, the black bear of North America is aroused with difficulty from his winter sleep, and this gives ground for the belief that he differs from the other species of bears in that he hibernates while the others do not.

The most perfect hibernating animal we have in Canada is the ground-hog (woodchuck), which hibernates in a burrow of its own

[2] These names—noctule and pipistrelle—are the common names of two species of European bats; the genus *Pipistrelle* is represented in North America, but only in the extreme southern portion of the United States, by three species and two subspecies. The common bats of eastern North America are the hoary, brown, silvery, red and the little brown bat, all of which are found here in British Columbia except the red variety.

[3] Bats undoubtedly migrate; see Miller, "North American Fauna," No. 13.

[4] Old term.

[5] The "brown bear" is a very loose term—the cinnamon bear is only a color phase of the common black bear. The grizzly may be any color and are subgenerically distinct from the black bear. It is doubtful if any bear is completely torpid during hibernation; the grizzly is much less so than the black bear, the period of hibernation being shorter.

making. In Europe the hedge-hog[6] (an insectivorous animal) is most complete. It retires to a hole among rocks, under a tangled mass of roots of trees or sometimes into an old disused drain, there it remains for the winter, seldom or never awakens until spring, and during this time it takes no food. In Canada it wakens to eat. If disturbed, it draws a deep sononous breath, followed by a few weak respiratory movements, returning almost immediately to its deep state of torpor and quiescence. The tuerec, an allied animal, found in Madagascar, sleeps similarly in its burrow for three months during the hottest period of the year.

None of the American (or European) squirrels truly hibernate[7] except the chipmunks (Entamicæ) and the ground squirrels (spermophiles).

The dormouse hibernates in the strictest form and its torpid condition is much deeper than that of the squirrels, its favorite bed for its long slumber being an old bird's nest or a mass of dried moss or feathers. In captivity, this little animal has been known to sleep for several days during the summer. The myoxus, an allied animal, when brought to Europe from Africa, hibernated in the winter seasons as if it were its usual and natural habit, without sustaining any harm.

The hare will lie beneath deep snow for several weeks at a time, in a cavity just large enough to contain its body. In a similar manner, sheep, without any apparent injury, have been known to live for several weeks, buried in huge snow drifts or slides.

All the amphibia hibernate in cold and temperate climes. Land tortoises bury themselves in holes in the ground, while the fresh-water tortoises bury themselves in the mud at the bottom and sides of lakes and ponds. They obtain a deeper condition of torpidity than that of hibernating mammals, digestion and respiration (lung) being entirely suspended. Frogs hibernate in masses in the mud at the bottom of stagnant pools and if awakened from the hibernating state by warmth, can remain underwater, without drowning, considerably longer than they can during the breeding season. That frogs (toads?) can remain in a state of hibernation for an indefinite period remains to be proved, but too many circumstantial accounts have been reported of the discovery of live toads in masses of solid coal or rock formations to allow the idea to be dismissed as fabulous.[8]

Reptiles, fish and batrachians exhibit little change from their usual

[6] Hedge-hog; this term hedge-hog is confusing; it is the term applied in Maine and New Brunswick to the common porcupine.

[7] In Canada, both the porcupine and squirrel store up food for winter consumption, rousing themselves at irregular intervals to eat.

[8] "Our common toad hibernates in the ground, as does the wood frog (*Rana sylvaticus*) and the small jumping frogs (*Hyla*). Our newts also hibernate in the ground."—John Burroughs (private communication).

condition (?). Lizards and snakes retire to holes in trees, under stones, dead leaves, and many species may congregate together in large numbers. They are in a quiescent and somnolent state, not true hibernation.

Fish of the temperate zone do not fall into a state of complete torpidity, but their vital functions are diminished and they retire to sheltered holes and cease to go abroad in search of food. In the tropics (Africa and India) large numbers of fish are known to survive long and severe droughts during which the streams and ponds are completely dried up. This, they do, by passing the dry season embedded in the mud.

Most of the species of molluscæ hibernate. The land snails bury themselves in the ground or conceal themselves under the bark of trees; in fact in almost any sort of a cavity to be found. They close the mouth of their shells with a calcareous plate technically known as the "epiphragm," and this is perforated by a minute hole to permit breathing. The substance forming this plate they secrete in their mouths. During the dry weather in summer, the snails bury themselves in the ground and cover the opening of their shells with this protective shield, but it is much thinner than the one used in winter. This they do to protect themselves from the drought, *i. e.*, by checking evaporation. Slugs bury themselves but do not enter into a complete state of hibernation. Fresh-water molluscæ go into a state of hibernation in the fall, burying themselves in the mud until spring. It is believed that salt-water molluscæ hibernate in a similar manner, but practically nothing is known concerning them.

Many butterflies and moths hibernate in the perfect state as well as in the form of imagos, but not in the larval state (?). Most insects which pass the winter in a state of larvæ hibernate during the period when they can not obtain any food. Insects which hibernate do not pair until spring and bees do not hibernate at all. It is well known to bee-keepers that these insects need plenty of food during the winter months.

In the seeds of plants and in the eggs of many of the lower animals, life may remain dormant for years in cold climates, until heat or moisture awakens them. Many plants die down, while their roots remain alive during the winter season (perennials and biennials), coming to foliage and blossom in the spring. In the same way trees shed their leaves in the autumn and the sap returns to the roots. Similar phenomena take place in tropical countries during the hot season, whenever the amount of humidity in the atmosphere is sufficient to maintain perennial vegetation during the entire year.

These phenomena in the vegetable world are regarded generally as being analogous to those of hibernation in animals and therefore the terms "hibernation of plants" is sometimes applied to them.

Physiology

In this article, so far, we have dealt with the natural-history side of hibernation, explained what is meant by the various terms used in connection with this state and in what respect the condition itself differs in the various animals subject to its peculiar manifestations: a condition provided by nature to tide an animal over a period when its very existence, owing to scarcity of food, becomes too difficult or even impossible to maintain; so by preserving the animal's life allows it to perpetuate its species.

We will now pass on to consider the purely physiological phases and phenomena of this state.

In hibernation all the activities of the body are greatly reduced, the temperature of the animal is lowered and even falls to a point slightly above that of the surrounding media. As it has been pointed out above, animals which hibernate do not belong to any one class, but examples are met with in mammals, reptiles (?), amphibians, insects, molluscæ, but curiously enough, no case is known among birds.

In some cases, previous to entering the hibernating state, the animal stores up food in its den or nest, on which it feeds when it wakes at intervals during its winter sleep. This is hardly pure hibernation, as in the true cases there is a special accumulation of fat in the animal's body before the commencement of the torpid state (the animal not waking to feed) and this serves as food during the hibernating period. A peculiar physiological change is here involved—a herbivorous animal becomes carnivorous, this being caused by the animal living on its own flesh, hence the excretions (small) of the animal become profoundly and completely altered in their chemical characters.

A low temperature is the cause generally assigned for the production of hibernation, but a more careful consideration of the facts long ago showed that cold could not be the sole cause of the phenomenon. Most observers who have worked on the subject have found that extreme cold will not cause an active animal to hibernate; although Saissy has observed that continued cold, and a limited amount of air for respiration caused a marmot to pass into a typical hibernating condition, even in summer. Against this we have Vernon Bailey's experiments with spermophiles (first cousins of the marmots or ground-hogs), which showed that in the case of hibernating animals a few degrees lower temperature changed the torpid state into one of death.

Mangili found that torpid marmots and bats were awakened by exposure to severe cold and that lessened or confined air would not cause hibernation. Dormice have been kept in a warm room throughout the winter and yet they hibernated and were not aroused when the extreme temperature was 20° C. The warmth, however, delayed the onset of torpidity by two months and made it less profound. Again, as has been mentioned before, hibernation may take place in the dry hot season.

The supply of food may also be a factor producing this condition, as torpidity in dormice and groundhogs is delayed or prevented when the food supply is plentiful. I question this for the following reasons: Spermophiles and marmots retire for their winter sleep when their food supply is at its best; they only remain active until the full coating of fat is acquired. Here in British Columbia they will retire a month or more earlier in the low lands than they do at the timber line. In the latter regions they have not acquired enough fat until the end of September, as they come out of hibernation later in the spring.

In this connection it is interesting to note the influence of the food supply on man, protectively causing a condition closely resembling hibernation. For instance, there is in Russia a certain class of peasants who suffer from a chronic state of famine which becomes more acute at the end of the year and more or less severe according to circumstances. In these cases, when the head of the family sees, towards the end of autumn, that by a normal consumption of their supply of wheat it will not last the family through the winter, he makes arrangements to diminish the rations as much as possible. Knowing that it will be difficult to preserve their health and keep up the physical force necessary for their work in the spring, he and his family plunge themselves into a condition known as "lejka" which means that everybody simply goes to bed, lying down on the top of the flat stove, and there they stay during the four or five months of winter. They get up, during this time, only to replenish the fire, eat a small piece of black bread and take a small drink of water. The peasant and his family try to move as little as possible and sleep as much as they can—stretched out on the stove top, they preserve almost complete immobility. Their only care during the long winter is to keep down the body metabolism, to waste as little as possible of their animal heat, and for that reason they try to eat and drink less, move less, and to generally reduce the activities of their bodies. Their instinct commands them to sleep as much as possible—obscurity and silence reign in the hut where, in the warmest place, either singly or crowded, the occupants pass the winter season in a condition closely resembling hibernation.

The following observations are purely physiological phenomena, occurring in mammals only.

Respiration

The frequency of respiration is greatly diminished, the rhythm is irregular and often of the Cheyne-Stokes type.[9] What little respira-

[9] In the Cheyne-Stokes type of respiration, there is a pause in the respiratory act, then a small respiration occurs, to be followed by a deeper one; then a still deeper act and so on until the maximum is reached, when the respirations begin to gradually diminish until they die away altogether. This is followed by a prolonged pause, then they gradually begin again.

tion (*i. e.*, interchange of gases in the lungs) there is, when the thoracic muscles and diaphragm are not acting (*i. e.*, complete cessation of movement) is maintained principally by the "cardio-pneumatic" movement.[10] A hibernating dormouse may not give a single respiration for ten minutes, then takes from ten to fifteen breaths, at the end of which it again lapses into a state of quiescence for a period of several minutes, when the spasmodic respiratory act again occurs. The same animal, when in a normal waking state, breathes at the rate of eighty or more respirations a minute. Similar results are obtained in other animals. It has been observed that hibernating bats and marmots could be kept for hours in an atmosphere of carbon dioxide gas, without suffering any ill effects, whereas a bird or rat placed in the same chamber died almost at once, thus showing that in the hibernating state the consumption of oxygen is extremely small or in other words very little oxygen is required by the hibernating animal (owing to the quiescence and lowered metabolism of the animal and naturally for the same reasons very little carbon dioxide is given off). Saissy has observed that the amount of oxygen taken in by a dormouse varied according to the activity of the animal, and so in true hibernation the amount of the intake of oxygen is naturally very small.

Circulation

During hibernation, the force and frequency of the heart-beat is greatly reduced. In the case of the bat and dormouse, it is as low as fourteen or sixteen per minute, while in these animals in the active state it is one hundred and over. Hill and Pembry by applying a stethescope to the chest of a hibernating bat, make the observation that no sound of the heart-beat could be heard, I can confirm this observation as applying to the hibernating ground-hog in British Columbia, also, whereas with the animal awake and active, the sounds were so loud that they could be heard distinctly when the ear was an inch away from the animal.

I have found, and can confirm other observers, that the blood during hibernation has an arterial hue (bright red) in the veins, and, on the other hand, Marshall Hall states that it has a venous color in the arteries.

Digestion

The activities of the digestive organs vary according to the habits of the different animals. Some, much as the dormouse, marmot (?) and hamster, store up food in the autumn which they consume during the winter in their waking intervals. Naturally, then, their digestive

[10] Cardio-pneumatic movement. Here the visible movements of respiration, dilation and contraction of the thorax, have ceased, but still air (a very small amount) is drawn into and expelled from the lungs. This is due to the heart's action, it also being contained in the thoracic cavity, hence its contraction and dilation so alters the pressure in the thorax that an interchange of respiratory gases is produced in the lungs.

organs are intermittently active. In the black bear, however, digestion is completely suspended and his intestines become plugged up with an indigestible mass composed chiefly of pine leaves. This mass is not discharged until the bear wakes in the spring.

It may be well to note here the important part played by the liver during hibernation in maintaining the animal's life; it acts as a storehouse, storing up energy in the form of glycogen, often called animal starch—a substance derived principally from starchy or carbohydrate food. This glycogen is converted in the liver into sugar and poured into the circulation, which carries it to the tissues, where it is consumed during hibernation, as well as in the waking state. The presence of glycogen in the liver-cells of the frog and other animals may actually be seen by the aid of the microscope, immediately before hibernation, and its absence, more or less complete, at the end of this period, demonstrated in the same manner. (This is disputed by Weinland and Richl —they claim that the amount of glycogen in the body remains constant during hibernation.

Nervous System

The excitability of the whole nervous system is greatly depressed. Physiologically, it resembles, as do the other tissues, that of cold-blooded animals in general, in that all the tissues (muscular, particularly) retain their excitability for a long time after they are removed from the body.

Temperature

A warm-blooded animal during hibernation loses all control (reflex) over its temperature-regulating mechanism, and acquires all the characteristics of a cold-blooded organism, that is, instead of its body having a regular, normal and steady temperature, its temperature becomes about the same as the surrounding media, and as this rises or falls, so does that of the animal. On the other hand, by arousing a dormant animal from its stupor, it is possible to make it exercise enough to bring its temperature up to normal, *i. e.,* what it would be in its ordinary walking and active circumstances, or in other words to bring it back to warm-blooded conditions again.

On studying the changes in external temperature, we find that the output of carbon dioxide and the temperature vary with the activity of the animal. If the animal is very active, it responds to a fall in external temperature by more muscular activity, and by this way maintains the normal heat of its body. If, however, this animal is in a sleeping condition and there is a sudden fall in temperature, it somewhat arouses at first, becomes active, and this causes an increase in the output of carbon dioxide, but after a few minutes it coils itself up again and returns to its former somnolent condition, and from which it is not so readily aroused. It has also been observed that when the surrounding temperature has been raised, the temperature of the

hibernating animal does not keep much above it, until a point is reached when the animal wakens. Then its temperature rushes up many degrees in a few minutes and at the same time the excretion of carbon dioxide becomes enormously increased.

Immunity and Formation of Antitoxine

Hansmann describes the influence of temperature on the incubation period and the formation of antitoxine. He found much greater resistance to infection and lengthened incubation time and no production of the various antibodies during hibernation. Blanchard and Blatin made the observation that in the hibernating condition the marmot was immune to parasitic maladies.

Conclusion

It may be stated and accepted that when hibernation has been fully investigated, all degrees of cessation of functional activity of the various organs and tissues will be found represented, from the normal sleep of man and other animals to the lowest degree of activity manifested in life. Though some observers claim that in true hibernation there is complete cessation of function in some organs, as, for example, the lungs and movements of respiration, this is extremely doubtful. The awakening of an animal from its winter sleep is never sudden, but slow and gradual, often lasting for hours. This gradation from a passive to an active condition is no doubt protective to the vital machinery, as it has been noticed that when bats have been awakened suddenly they have quickly died.

We have spoken of hibernation in man, and by some authorities, sleep in man is closely allied to a state of hibernation. Natural daily sleep is favored by moderate exhaustion, the cravings of hunger being satisfied, and the absence of all peripheral stimuli. Sleep is a rhythmic diminution of the activities of all the tissues, but especially of the nervous system, which has control of all the others. As we have mentioned before, Marshall Hall and others have shown that the gaseous interchange in a hibernating animal is greatly lessened and so too it is in sleep. It has also been shown by experiments that hibernation, like daily sleep, is not a series of fixed and rigid phenomena, but is varied in depth and in season and its main use is that of protecting and conserving life.

All forms of profound winter and summer sleep are protective, both of the individual and of the species. If it were not for this act of hibernation, many of the mammalia, amphibia, as well as some other groups of animals, would be utterly destroyed from the face of the earth.

THE HOME OF THE ALLIGATOR

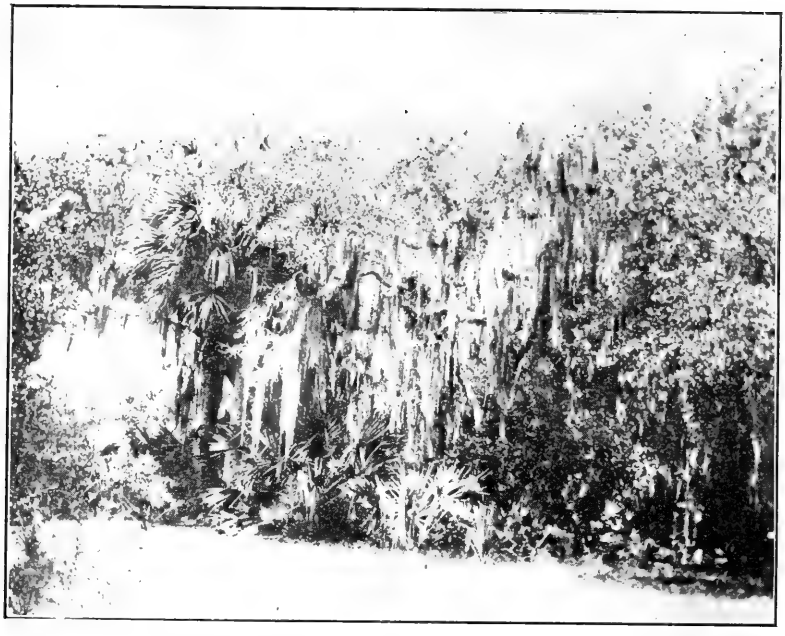
By Professor A. M. REESE
UNIVERSITY OF WEST VIRGINIA

IT has twice been my privilege to visit the wilds of Florida under the auspices of scientific societies, the first trip being to the Everglades, while the second expedition, under the auspices of the Smithsonian Institution, took me to the flat-wood and prairie regions in the center of the state, far from railroads and other signs of civilization.

From the pleasant little town of Orlando, with its orange groves and numerous small lakes, we plunged almost immediately into the "piney-woods," where the road is scarcely more than a trail, and is strewn with numberless huge pine cones that produce constant and nerve-racking jolting to passing vehicles.

For about thirty miles we drove, slowly on account of heavy loads, through the pines, where but few and widely separated houses, and no villages, worthy of the name, were to be seen. The monotony and loneliness of these almost perfectly level forests, broken only by an occasional cypress swamp, sluggish stream, or tiny cabin, becomes, to one accustomed to a thickly-settled, rolling country, quite oppressive; and we were glad to come suddenly to the edge of the forest where we could look out for miles upon the open prairie. The prairie proved to be much more interesting, though no less lonely, than the pine woods. The ground is here covered with either grass, upon which large herds of cattle feed, or with the "scrub palmetto" which is, apparently, gradually spreading its useless foliage over the entire prairie.

These scrub palmettoes, especially where they grow in taller, denser groups, are the home of numerous diamond rattle-snakes, the most deadly of American reptiles. As we drove past the palmettoes we frequently saw, and always captured alive if possible, these deadly rattlers, my guide being very expert and perfectly fearless in handling them. If they were coiled when found, he would simply reach out his hand slowly and pick them up by the back of the neck, sometimes attracting their attention by dangling a handkerchief in front of their eyes with one hand while he seized them with the other. If they attempted to escape, he would tap them with a carriage whip until he made them crawl where he could get at them easily. It is remarkable the amount of teasing and rough handling to which a rattler will submit without attempting to bite. His rattle may whirr violently and



A Typical Florida "Hammock."

The Interior of a Florida "Hammock."

he will look as threatening and deadly as any animal could, but, unless he be shedding, he will seldom strike if he can avoid it by escaping from his tormentors.

Although he had been handling and collecting snakes for thirty years, my guide had, until this trip, never been bitten by a rattler. One morning he had caught, in a noose at the end of a pole, a large rattler that was shedding and was, therefore, very vicious. Where a snake was lying in an inaccessible place, or was, as in this case, unusually

LEAVES OF THE "CABBAGE PALMETTO."

vicious, a noose was generally used and the snake thus transferred to a bag carried for the purpose. As he was being lowered into the bag, this particular snake gave a sudden twist and one of his poison fangs cut a long gash in the hand of his captor. Fortunately for the man, only the extreme tip of the fang penetrated the skin, so that little or no poison was injected. The guide always carried a hypodermic syringe for just such emergencies, so that a dose of potasium permanganate was soon injected into the wound, and no ill effects from the bite were felt.

Although the bite of these rattlers is not necessarily fatal to man, almost any one in that region can tell of one or more cases where death has followed within a few hours of the time that the wound was inflicted.

CAPTURING A DIAMOND RATTLER.

villages would be in other states: Camp Hammock, Hickory Hammock and Jack Hammock are familiar names in that region. They serve as camping places for men, and as shelters from the noonday sun for cattle. Some of them, when entered, are veritable fairy-lands: from the branches of the huge live oaks are festooned great masses of beautiful, gray, hanging moss, while here and there is stationed a stately palmetto, with its great head of green leaves, each leaf nearly twice as tall as a man. From the lower growth may project the gaunt, bare branches of a dead oak, on which a group of turkey-buzzards and carrion crows are likely to be seen.

The much smaller ground rattlers are also numerous on the prairie, but, on account of their small size, one to two feet instead of six to eight, they are not feared as are the diamond rattlers.

The monotony of the prairie is broken by an occasional clump of trees, known as a "hammock" (probably derived from "hummock"). These hammocks are sometimes composed merely of a small group of palm trees, called "cabbage palmettoes" from the edible, cabbage-like core at the tip; or they may cover several acres and contain moss-hung oaks and a dense undergrowth. The hammocks serve as landmarks and milestones for the traveler and cowboy, and many of them are named, just as streams, hills or

A GROUP OF CARRION CROWS.

Except for the flatness of the country, which makes the drainage uncomfortably slow in wet weather, a more delightful place to pitch one's tent could hardly be found than one of these Florida hammocks. To be sure there are numerous snakes (we caught no less than twenty-three in a hammock where we camped for about a month), but they are mostly of harmless varieties and are really very graceful and interesting animals.

Dotted over the prairie are numerous small swamps and sluggish water-courses: the latter are called "sloughs" (pronounced "slews"), and differ from the former in containing, at least during wet seasons, running water. These swamps and sloughs are the home of the alligator and the deadly cotton-mouth moccasin. While searching for the

A Typical 'Gator Hole of Central Florida.

nests of the former, the latter were frequently seen, but were left severely alone, as they are quite deadly, are much more aggressive than the rattlers, and have no warning rattle to indicate the state of their tempers.

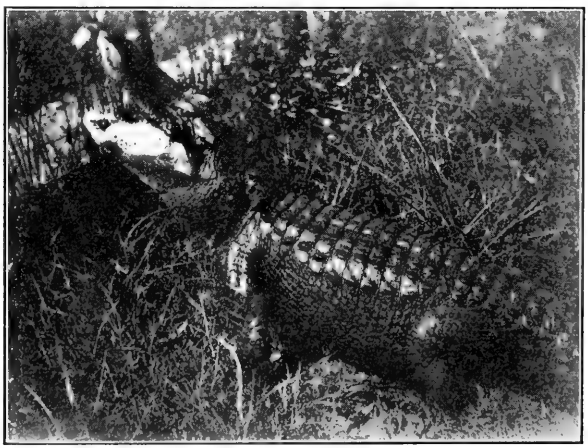
In these swamps we collected not only several hundred alligator eggs, but also numerous alligators themselves, both large and small. The baby 'gators were hooked up out of the water with a wire noose on the end of a bamboo pole, while the large ones were either shot directly or were pulled out of their caves under the banks and killed by a rifle bullet in the back of the neck.

A NEST OF THE FLORIDA ALLIGATOR, made of a mass of flags and grasses. The nest has been opened to show the pile of eggs within.

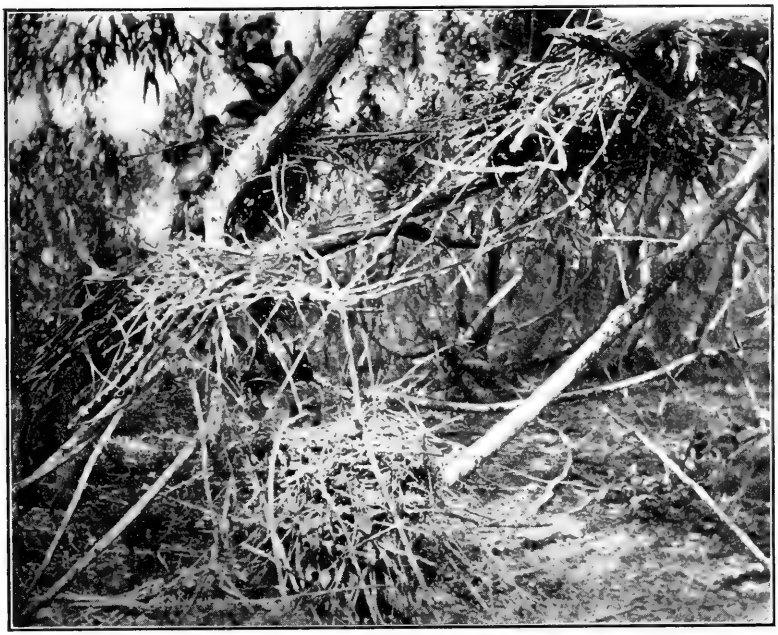
In the tall grass about the swamps deer are frequently seen, while on other parts of the prairie wild cats, skunks and other animals are met with; and rabbits are so abundant and so tame that they may be killed with a long pole or snared with the noose used for capturing young alligators.

Herons, cranes, ibis and other beautiful and interesting birds are constantly seen, so that the naturalist has something of interest before his eyes at every turn.

For the ornithologist, professional or amateur, who wishes to study and photograph an interesting bird colony, as has been done by Chapman with the flamingoes and by other naturalists, there is, on a small



AN EIGHT-FOOT FLORIDA ALLIGATOR.



FOUR NESTS OF THE WHITE IBIS, within a radius of three feet, on Bird Island. Several nestlings, which are black at this age, are to be seen.

island near the center of Lake Kissimmee, an excellent opportunity. Lake Kissimmee, which is about thirty miles long by five wide, lies at almost the exact geographical center of the state of Florida. It may be reached by driving, as in the present case, or by motor-boat from the town of Kissimmee on the Atlantic Coast Line Railroad, at the head of Lake Tohopekaliga.

The island in question is well named "Bird Island," for it is the nesting place of thousands of white ibis, and not a few other birds. Its situation in the center of the lake makes it a safe retreat from the wild-cats and other destructive animals of the mainland, while the neighboring swamps furnish an endless supply of food for both old and young birds. For miles in all directions flocks of ibis, from three or four to as many dozens in number, may be seen feeding in the swamps and sloughs, or flying, single file, with their characteristic alternate flapping and sailing, to and from the rookery on the island.

The island itself is covered with a dense jungle of reeds and undergrowth, with areas of bushes and small trees. When one pushes through the reeds into one of the bushy areas, there is a startling whirr of wings as thousands of the ibis take to flight, circling about overhead in a perfect cloud, and making a most beautiful spectacle.

At the time of our visit to the rookery, about the middle of July,

nesting was in full swing, and in all stages, from the egg to the nearly full-grown bird. The nests, crude affairs, each made of a handful of small sticks, were everywhere—in every available situation on the bushes and small trees, and scattered over the ground in such numbers that one had to walk with care to avoid stepping on them. In some nests were eggs, as has been said, while in others were birds of all sizes, the larger of which scrambled away awkwardly at our approach. With a proper shelter it should be an easy matter to get any number of photographs, at closest range, of these interesting birds. Circling overhead was a flock of crows, watching for opportunities to swoop down, in the absence of the parents, and carry off the young birds from the nests.

A Heron Posing for his Picture. The Bird Island Rookery, Lake Kissimmee, Florida.

For studying reptiles and birds there is probably no more interesting locality in the United States than this subtropical region of central Florida; and if the ubiquitous gun sportsman can be kept away, the hunter with the camera may there enjoy his harmless and instructive sport for many years to come.

The writer will be glad to furnish information as to equipment, guides, etc., to any camera sportsman who may be interested; powder-and-shot sportsmen need not apply.

THE OWEN BILL FOR THE ESTABLISHMENT OF A FEDERAL DEPARTMENT OF HEALTH, AND ITS OPPONENTS

By S. ADOLPHUS KNOPF, M.D.

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ANY one who is familiar with the workings of governmental departments of health such as exist abroad, who has seen or experienced the sanitary benefits bestowed upon the people by the Reichsgesundheitsamt of Germany (imperial department of health), the Conseil Superieur de Santé Publique de France, and the similar institutions of most European governments, can not help feeling amazed that any opposition should exist to the establishment of a federal department of health in this country. This amazement becomes all the greater when one considers some of the elements of which the opposition to that measure is composed. There is, for example, the New York *Herald,* a large and influential newspaper with an honorable career and a brilliant record for advocating everything that is conducive to the public welfare. Only in this particular instance has it allowed itself to become the mouthpiece of principles to which it is in general opposed, that is to say, principles and measures whereby the good of the people at large and the progress and welfare of mankind are hindered, and the lives of individual American citizens endangered. This particular newspaper is independent of any political party, or professional or religious association which might prejudice its point of view, and still it opposes a measure whereby all citizens of the country would benefit. The writer can not help thinking that this powerful news organ has not informed itself thoroughly of the real purpose and function of a federal department of health, and in its attack upon a large body of men such as compose the American Medical Association, the American Public Health Association, the National Association for the Study and Prevention of Tuberculosis, the American Association for the Advancement of Science and the various medical academies of the country, it is certainly misguided. It is to be hoped that the distinguished editors of the New York *Herald* will soon see that in their attitude toward the Owen bill they are not on the side of the people but are working against the welfare and interests of the masses.

The principle of the Owen bill, establishing a department of health, has been endorsed by the president of the United States, by General George M. Sternberg, surgeon-general of the army, retired, and Rear-

Admiral Charles F. Stokes, surgeon-general of the navy, by General Walter Wyman, of the Public Health and Marine Hospital Service, by Dr. Harvey W. Wiley, of the bureau of chemistry, by governors of states, by the Conference of State and Territorial Boards of Health, by the United Mine Workers of America, by the National Grange, by the republican and democratic platforms, and by numerous other organizations.

What is the principle of this bill which is advocated by thousands of men trained in medicine or sanitary science and interested in the public welfare?

Section 7, which embodies the main purpose of the Owen bill, reads as follows: "That it shall be the duty and province of such a department of public health to supervise all matters within the control of the federal government relating to public health and to diseases of animal life."

Section 2 of this bill deals with the unification under a secretary of public health of the various agencies now existing which affect the medical, surgical, biological or sanitary service.

There has recently been formed an organization which calls itself "The National League for Medical Freedom." It has for its purpose to combat the Owen bill; it is opposed to the establishment of a federal department or bureau of health. The name of this organization is certainly, if not intentionally, misleading. It can not claim to battle for medical freedom, for there is not a word in the entire bill which could be interpreted as limiting the practise of medicine to any particular school. Their claim that the establishment of such a bureau of health would have any resemblance to a medical trust is entirely unfounded.

The life insurance and industrial insurance companies which advocate this bill certainly have no desire to limit medical freedom or to repress any system which offers the chance of lengthening human life. These companies do not favor medical partisanship and their sole interest is to prolong the lives of their policy-holders by whatever means possible. Their actuaries state specifically that they believe human life could and would be lengthened by the establishment of a federal department of health.

Lee K. Frankel, Ph.D., representing the Metropolitan Life Insurance Company, is a member of the Committee of One Hundred, appointed by the American Association for the Advancement of Science to further the propaganda for the establishment of such a department. Neither the above-mentioned great newspaper nor any of the leading spirits of the "National League for Medical Freedom," all of whom, I regret to say, have allowed themselves to ascribe the worst motives to the members of the committee, will deny that the names of the officers

of this committee show that it is thoroughly representative of the highest type of American citizenship. The officers of the Committee of One Hundred are:

President: Irving Fisher, Ph.D., professor of political economy at Yale University.

Secretary: Edward T. Devine, Ph.D., LL.D., professor of social economy, Columbia University, and secretary of the New York Charity Organization Society.

Vice-presidents: Rev. Lyman Abbott, D.D., LL.D., emeritus pastor of Plymouth Church, editor of *The Outlook;* Jane Addams, A.M., LL.D., founder and head worker of the Hull House Settlement, ex-president of the National Conference of Charities and Correction; Felix Adler, Ph.D., professor of political and social ethics, Columbia University, leader of the N. Y. Society for Ethical Culture; James B. Angell, A.M., LL.D., professor of modern languages and literature and president emeritus of the University of Michigan; Joseph H. Choate, LL.D., D.C.L. (Oxford), diplomat and United States senator; Charles W. Eliot, A.M., LL.D., president emeritus of Harvard University; Rt. Rev. John Ireland, LL.D., archbishop of St. Paul; Ben. B. Lindsey, judge, reformer and author, Denver, Colo.; John Mitchell, president of the labor union of America; William H. Welch, M.D., LL.D., professor of pathological anatomy, Johns Hopkins University.

Need I say anything in defense of the Committee of One Hundred after having given the names of its officers?

Direct and most unkind comments, not to use a stronger term, have been directed especially against one vice-president of the committee representing the medical profession. I refer to Dr. William H. Welch, M.D., LL.D., president of the American Medical Association. Those who know Dr. Welch and even those who only know of him, would justly think it absurd if I should see the need to say even a word in defense of this master of medical science. To us it is indeed difficult to understand that there would be any man or woman in this land capable of speaking ill of Dr. Welch. There is no name in the medical world which is more honored in this country and abroad, no medical teacher more admired, no one who has a larger following than this Johns Hopkins professor of pathology, and no physician more beloved and looked up to as representing all that is best and noblest in the profession than Dr. Welch. If there is any man in the American medical profession who is unselfishly devoting his high intelligence, his time and his means to the public welfare it is Dr. Welch. Gladly do we acknowledge him as our leader.

To accuse the president and members of the American Medical Association of selfish motives in advocating the establishment of a federal department of health is absurd. If there ever was an unselfish

movement inaugurated, it is this one. It is a movement by physicians for the reduction of disease, which *ipso facto* means a movement against their financial interests.

The writer is a member of the regular profession; he nevertheless would not wish for a moment to limit the freedom of any citizen to choose his physician from some other school or cult, providing the individual assuming the function and responsibilities of a physician had the training necessary to prevent him from endangering the life of his patient by lack of medical knowledge or skill.

The official mouthpiece of this "National League for Medical Freedom" is Mr. B. O. Flower, who has had heretofore the reputation of a fighter for everything involving the spiritual, social and physical progress of humanity, and it is inexplicable to many of his admirers how he can lead a movement opposed to the improvement of the health of the nation. The vast majority in the ranks of this so-called "league," though they may be well-meaning, noble, and earnest, are not men and women who have toiled patiently for years in order to acquire the thorough scientific medical training which enables one to assume that great responsibility of the care and treatment of the sick. They are unable to appreciate the inestimable value of federal help in preventing disease. These people are blindly following certain individuals who designate the regular profession as a medical trust, and accuse the thousands of noble men and women who are devoting their lives to the alleviation of human ills of a desire to monopolize medical practise. The establishment of a federal department of health would mean pure food, pure medicine, control of plagues and epidemics, the advancement of medical science and through it the improvement of the health and increase of material wealth of the nation. It is said that many of the individuals opposing the Owen bill are commercially interested in the manufacture of drugs or patent medicines, of which latter the American people swallow about $200,000,000 worth annually. Whether it is true or not that the National League for Medical Freedom is backed financially by drug manufacturers and patent medicine concerns, I am not prepared to say; yet even these men have nothing to fear from a federal department of health if the drugs they put on the market are pure and the claims made for patent medicines do not delude the public or endanger its health. The element which clamors most loudly for medical freedom is composed in many instances of men and women who have attended one or two courses of lectures or got their "degrees" without any training at all, and have developed into "doctors" and "healers" in a most remarkably short space of time.

Because the American Medical Association has always advocated a thorough medical education, is pleading constantly for pure drugs, is opposed to quackery, patent medicines and nostrums, its 40,000 mem-

bers are considered a medical trust. Yet it is in the ranks of this very American Medical Association that are found the greatest number of unselfish devotees to preventive and curative medicine. It is within this association that are found the men who have added the greatest glory to the medical and scientific reputation of this country. America's greatest surgeons—Marion Simms, Gross, Sayer, O'Dwyer, Bull —were members of this association. McBurney, Jacobi, Stephen Smith, Welch, Osler and Trudeau have graced this association by their membership for nearly half a century. The heroes in the combat against yellow fever—Reed, Lazare and the hundred of others who have devoted their best energies and knowledge and often sacrificed their lives for the sake of medical science—were members of the American Medical Association.

One of the most illustrious members of the American Medical Association is its former president, Col. William C. Gorgas, of the U. S. Army, chief sanitary officer at Panama, an adherent to the regular school. It is thanks to the genius, the scientific and thorough medical training of Dr. Gorgas that the formerly deadly Isthmus of Panama has now become as sanitary a region as any. A great patriotic enterprise, important to commerce and the welfare of nations, was made possible by this man. He has labored and is constantly laboring for the establishment of a federal department of health because he knows the inestimable benefit which such a department would bestow upon the nation.

Whatever advance has been made in medical science in America or in Europe has been made by scientifically trained men or by physicians not without but within the ranks of the regular profession. The greatest benefactors of mankind are those who diminish disease by prevention and cure. As another illustrious example of medical benefactors, may I be permitted to cite that great trinity of scientific giants who through their labors have accomplished so much in reducing disease and lessening human misery in all parts of the globe? They are Pasteur of France, Lister of England and Koch of Germany; all of them aided their governments by direct participation in the governmental health departments. We are still mourning the death of perhaps the greatest of the three—Robert Koch. I do not believe that there is, even in the camp of our opponents in this so wrongly called "League for Medical Freedom," a single intelligent individual who will deny the inestimable benefits which Koch has bestowed upon mankind through his discovery of the germs of tuberculosis, of cholera, of the spores of anthrax, of tuberculin, and through his many other equally important scientific labors. Yet, had it not been for the Imperial German Reichsgesundheitsamt, which is the equivalent of the institution we are striving for—a federal department of health—Koch

never would have been able to devote his life, energy and great genius to those important discoveries through which thousands of lives have been saved in all civilized countries during the past few decades. It was while working in this governmental institution, which is doing exactly the work the Owen bill asks the federal department to do, that Koch discovered the tubercle bacillus and the bacillus of cholera. Because of the discovery of the comma bacillus, we no longer have those fearful cholera epidemics which formerly decimated our own and other countries. This disease can now be easily diagnosed and by proper quarantine its mortality can be reduced to a minimum. And what shall we say of the progress that has been made in the fight against tuberculosis because the federal department of health of Germany enabled Koch to do research work and thus discover the bacillus of tuberculosis to be the primary and only direct cause of the disease? As director of the hygienic institute and member of the Reichsgesundheitsamt he inaugurated that wonderfully effective campaign against tuberculosis whereby the mortality from this disease in Germany has been reduced to nearly one half of what it was prior to the discovery of the tubercle bacillus.

Under Koch's inspiration and guidance and in the same institute many great scientific discoveries of incalculable value to humanity were made. Foremost among them are the works of Ehrlich, one of Koch's most celebrated pupils, who recently gave to the world a new remedy which promises to prove a specific in an affliction from which mankind has suffered for centuries.

As co-worker in the Kaiserliche Gesundheitsamt and the Institute for Infectious Diseases, affiliated therewith, we must also mention Behring, the discoverer of the anti-diphtheritic serum. Thanks to the discovery of this serum thousands of young lives are now saved which would formerly have fallen victims to the terrible disease known as malignant diphtheria. This was made possible by the opportunity given to the workers in the Reichsgesundheitsamt and Imperial Institute for Infectious Diseases.

Can there be any better argument in favor of the establishment of a federal department of health?

THE DISTINCTION BETWEEN THE LIBERAL AND THE TECHNICAL IN EDUCATION

By Professor PERCY HUGHES
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THE terms liberal and technical do not distinguish two types of educational practise, but two tendencies in and functions of any part of the educational process. For at the present time any type of liberal education includes of necessity education for efficiency in some art, in the broadest sense of that term; while the existent types of technical education involve training that goes far to realize liberal ideals.

But, in any education, the tendency to emphasize the technical at the cost of the liberal function of that education is confronted with the reciprocal striving of the liberal tendency and ideal to maintain its ancient eminence and prerogative. The technical aim is to fit the individual to take his place in the social scheme of toil through efficiency in some art, whether it be teaching or engineering, medicine or "business." The liberal purpose is the realization in each individual of the highest manhood, of those ideals of character and personality which alone make the toil and sacrifice of society meaningful and worth while. It is possible that these two tendencies should cooperate and indeed proceed along identical lines of educational effort now, as they have done in times past. But it seems that under modern conditions which the school can neither at once change nor at all afford to disregard, the demand for technical efficiency is necessarily antagonistic to liberal aspiration—not indeed at all points, but in many respects.

I believe that it is of the greatest importance clearly to formulate and contrast these two tendencies in modern education, so that, in answer to the perfectly clear and exceedingly insistent demands for technical efficiency, there may be set forth ideals of liberal education which shall be well understood by all interested in education, and shall appeal to all as imperative and urgent.

Disregarding, therefore, accidental, partial and temporary phases of liberal education, we note, in the first place, that in styling an education liberal we thereby associate it with liberalism in politics, in philosophy and theology, and in men's personal relations to each other. In each case liberalism seems fundamentally to denote freedom, that is, the conditions that make for the development and realization in each individual of that character and personality which is his true nature. A similar argument leads to the conclusion that the technical in educa-

tion is directed toward efficiency in some art. (Here the term art is used in its original and broadest sense, to include any method of action that is recognized and adopted as the means appropriate to achieve some definite, specific purpose.) We may then conclude that an education is liberal in so far as it makes for manhood and personality, technical in so far as it makes for efficiency in some art. And we proceed to consider why it is that at the present time we find the liberal opposed to and contrasted with the technical trend of education.

In ancient Athens the aim set before each citizen was, fundamentally, to be a good citizen; and in mastering that art he realized also personality and manhood. Here the technical and the liberal in education seemed in perfect accord. And it was so in the Rome of Cicero and Quintilian, when the education of the orator was looked on as the fullest development of personality. And, in primitive and medieval Christianity, the fullest realization of the soul in that life-long education which should bring salvation in the knowledge and love of God was the very education which should fit the man also for the one supreme art, the extension of God's kingdom here upon earth. So too the knight, the warrior of the medieval system, could not distinguish the education which should make him a perfect knight, from that which should make him a perfect man.

During the renaissance there appeared and flourished a type of education which had in view the cultured gentleman, rather than the perfection of any art to which he might or might not apply his powers. But even here the liberal was not *contrasted* with the technical, though in later times there developed from this renaissance ideal the still persistent concept of a "gentleman" who might best attain culture when aloof from the general life of toil. But what is most noteworthy in the renaissance, whether we consider its birth in the free Italian cities, its culmination in Luther and Bacon, or its close in Milton, is not unworthily summed up in the ideal of education which Milton himself thus expressed: "I call therefore a complete and generous education that which fits a man to perform, justly, skillfully and magnanimously, all the offices both private and public of peace and war." Still then it was thought that a man might attain efficiency in every art and therein find his perfect freedom and full realization.

The sense of opposition between the liberal and the technical in education is not to be found in Huxley or in Spencer, who best express to us the scientific in contrast with the humanistic vision of liberal education. Indeed, both these men were criticized, even in their own day, for failure to see that to be "in harmony with nature" or to strive after a comprehensive knowledge of the various fields of science is not the best preparation for most occupations, and is indeed hardly possible in view of the necessity for the thorough acquaintance with some limited field of science and knowledge which modern conditions seem to demand.

For, as the development of the sciences has led to the elaboration and multiplication of the arts, and to consequent specialization in each field of art, even the gifted man finds himself forced to abandon the scientific and humanistic aspirations which have been identified with a liberal education, in order that he may attain some small success in a selected realm of practical art and achievement. Without for the present assuming that such specialization does indeed mean dwarfing and distorting of personality, we clearly have to recognize that it introduces a new factor into the situation, which at least tends to turn technical education from liberalizing paths, or seems to do so.

Another influence seems more obviously and directly to turn technical edueation from liberal ideals, viz., the fact that most arts now demand for their prosecution great sums of money. For this and for other reasons, no doubt, all arts have come to be looked on as in the first place parts of "business," and are followed and studied chiefly from the business point of view, in which the first consideration is to do that for which people will pay, and to make a profit. "Business" itself may be called an art; perhaps the art of money-making. But, while of other arts it often is true that they require of the efficient artist that he be very much of a man, no one claims, I believe, that the art of money-making "functions" very successfully in the enlargement and ennobling of personality. And, however much we may urge the student and worker in any field of art, other than that of money-making, to find within his work his reward, and to place the excellence of his art above all considerations of gain, we must admit that that view of technical pursuits is taken by but few men, save for "those brief moments when men are at their best."

Granting then the liberalizing potentiality of any technical education we may fairly inquire whether, in the presence of these two factors, extreme specialization, and the exaltation of money-making, the liberal tendency in and function of education is not greatly neglected and harassed. But in such an inquiry I would avoid the view-point of those who stand primarily as defenders of an ancient order of things, of an excellence the vision of which has bestowed upon them, but which is rarely granted to those who attain intellectual maturity under present conditions. The conception of a liberal education, that it stands for freedom, for the spontaneous realization in each individual of what in the fullest and truest sense he is, such a conception summons us to the unbiased study of the individuals born into the world as it now is, in order that we may afresh determine with their aid, for ourselves and for them, what means to adopt in order that the best in each of them may come to light. Yet, in thus adapting the liberal ideal and aspiration to present conditions, we of course reject neither the classic nor the scientific springs of culture.

It seems to me that evidence of an actual opposition between the liberal and the technical in education is found in three distinct evils which pervade the activities of society; and in each case it seems to me that the remedy for the evil lies only in adhering to and establishing the ideal of liberal education.

It is regarded as the business of the technically trained man to give people what they want, if they will pay for it. He is not expected to judge, or to be capable of judging, whether what is thus done makes for the development of human nature and personality. A shipbuilder is not expected to judge whether the object for which he builds the ship—war, it may be, or contemptible luxury—is a worthy object; the skilled advertising agent is not blamed if he collects money for the publication of a magazine much worse than useless, but permitted by law; the bridge-designer is not expected to see that his designs are executed under conditions that make for the safety and welfare of the workmen; the automobile manufacturer is not censured for the construction of machines ill adapted to run according to law, but excellently suited to break the law and to put other people to discomfort and in danger; the newspaper editor is not blamed for the destruction of acres of noble spruce trees sacrificed to the production of a "comic" supplement.

Even though we ask of the preacher and the teacher, of the physician and the scientist—yes, of the lawyer and the politician—that they have regard to the welfare of men in their several lines of art, and though such technical training as all these men may receive is not without reference to this liberal aspect of the professions they are to follow, yet we have to recognize that none of these professions is free from the general principle that people should get what they are willing to pay for, and not much else. And it must be confessed that in every line of technical education, with the partial exception of the training for teaching and the ministry, what little insistence there is upon the importance of the liberal conception of life and art, is not accompanied by thorough instruction in determining what ideals of manhood and personality are worthy and well founded. On the study of what things are of real worth much has been written (outside the literature of "revelation") which compares in solidity and scope of treatment with the best that the mathematician and the physicist have achieved in their fields of science. But the study of these teachings is at present largely neglected, and seldom systematic or continuous.

From the liberal standpoint the highest development of a man's personality involves the sense of a thoroughgoing responsibility for what he does, and the determination to decide for himself, so far as possible, whether what he does is, in its results upon human welfare, worthy of himself. No man surely is called free who acts without

appreciation of the significance of his acts. It is therefore the liberal ideal that a man must seek himself to be the first judge of his own acts, as to whether in the last analysis they are right or wrong. The conception that a man may do whatever he is paid to do, provided his acts do not come under the effective censure of the state, is no more liberal than it is lovely. It seems to be the neglect of the liberal ideal that has brought us face to face with our present condition in which talented and trained men are swifter to do evil than the will of the people is found ready to check the evil through laws.

The first element, therefore, of the liberal as distinguished from the technical function of education, at the present time, is that men trained for any art should know and fully recognize what things in life are of greatest worth, and should acquire the habit of acting according to that conception; especially in their own fields or art. While history, literature and philosophy seem to be the subject-matter through which such education may be given, it is obvious that their association with technical pursuits would need to be made much closer than is usual, if the aspect of liberalism which I have described is to be realized.

A second respect in which, I think, the liberal in education needs sharply to be contrasted with the technical drift in modern education, may be styled "appreciation." In some occupations, it is true, there is a strictly technical necessity that a man must grasp the scientific, social and esthetic significance of his task, if he is to do his work well; but in countless other lines of technical achievement, from the work of a factory hand to that of a railway president, it is idle to assert that a proper appreciation of these aspects of his work is essential to his technical success. And, indeed, it is essential that a man's appreciation of the meaning of his work should be cherished quite independently of any possibility of use and reward; though of course if the reward come, all the better. Freedom and the adequate realization of personality require that a man's work "have meaning to himself." Let him see within his work, in Dewey's words, "all that there is in it of large and human significance," and he will not be the slave of tomorrow's promised smiles.

There is no "job" that does not present innumerable phases of interest, and problems for investigation to the mind trained in physics and chemistry, none that is not linked in a hundred ways with all the problems and needs of the social organism, and with the history of man's effort and advance, his folly and despair. There is no task, I suppose, in which the eye and ear trained to appreciation may not detect features of beauty and romance and mystery. And to the philosophic mind the very monotony of the toil is linked with the tireless movement of ocean and planet, while the spirit that endures it is felt to be kin and near to the will and temper of heroes in all ages.

The habit of thus associating the richness of history, romance and science with one's daily work is found in some men, and is a source in them not only of technical efficiency, but of strength and joy. How little is such genuine liberalism fostered by the aristocratic conception of culture as a means of occupying leisure, or by our actual practise of dissociating the study of history, literature and philosophy from the common tasks of to-day! Perhaps the remedy lies partly in the introduction of industrial training into our schools, perhaps in the more common employment of teachers who have worked in shop and factory and office.

The third way in which under present conditions the liberal in education stands opposed to the technical, is in the recognition of individuality, the right of each individual to "yield," in Emerson's words, "that peculiar fruit which he was created to bear." In place of each man adjusting himself to his environment, which, technically speaking, means the present or anticipated demands of the buyer, Emerson invites the individual to "plant himself indomitably upon his instincts and there abide," for the huge world will come round to him. However exaggerated the language, the conception is fundamentally the liberal conception, viz., that the end of all our activities is nothing but the bringing to flower and fruit the highest perfection of which each man is capable. Whereas the technical view at present is to look on the individual as part of the machinery by which the "world's work" is done, that is, service is rendered for which people can be got to pay, the liberal view is to insist that the world's work is the cultivation of the garden of human life, and the best service a man can render is to offer the world the finest fruits of his own personality. Liberalism bids the man take counsel of his own spirit rather than of the market, and prophesies that in maintaining his stand in the face of the world he will gain a deeper insight of the essential harmony between himself and it, while lifting life to a higher scale of intensity and idealism.

By thus starting from the simplest possible conception of liberal education, as education for freedom, for the realization of personality, we escape from a narrow tradition, and from a false antithesis to industrial ardor and efficiency, and are left free to judge for ourselves wherein under present conditions true personality consists, to note without prejudice what evils the technical emphasis in education actually tends to nourish, and to devise under constantly changing conditions new ways for the protection and furthering of the liberal ideal. Clearly the defense of the liberal in education is not merely a matter of insisting on certain courses of study traditionally styled liberal; but, if I have correctly analyzed the situation, it is to cherish certain ideals and to train in certain habits, viz., in the evaluation of one's conduct in terms of its effect upon character, in the appreciation of the interest

and beauty that actually is present in our work, and in counting individuality, patient and prudent independence, of more significance than the world's approval or reward. Subsidiary to such ideals the classics, ancient and modern, have indeed their place, which is side by side, however, with modern science, in all its branches, and the alert observation of living men and existent things, which are at least as important instruments to such liberalism.

The reformation which thus appears necessarily would be furthered, in my opinion, by the formation in each school and university of one or more associations of instructors for the professed, deliberate and persistent study of the means through which the liberal spirit and purpose may be preserved and increased, first in themselves, second in the world at large, and finally in the student body. For liberalism can not be very effective in the curriculum until it is born again in our hearts and in the world at large. Few instructors seem to be less liberal, in the fundamental significance of the term, than many teachers of the subjects which are traditionally styled liberal. Personally, I look with most hope towards those young men who are conscious of the need without being committed by tradition and profession to any particular way of meeting the need, men, who, having their eyes fixed upon the industrial world as the place where men really live, earnestly ask themselves how the boys who are to toil there may take with them from home and school the habitual recognition that the ultimate aim of all modern industry is nothing but the exaltation of manhood, the free realization in individuals of the ideals of manhood.

THE TARIFF BOARD: ITS SCOPE AND LIMITATIONS

By SEYMOUR C. LOOMIS
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EMINENT authorities on civil government lay down the rule that certain questions should be left to the people or their representatives in a legislative body, and certain other questions should be decided by experts: the latter, not because experts do, or do not, represent the people, but because they are more familiar with the subject-matter and better able to reach a correct determination. Upon this principle our federal and state constitutions have separated the legislative from the judicial department. The legislature is chosen particularly to represent the people; the judiciary, because of its knowledge of the administration of the law.

Many, if not most, public questions arising in a republic, may properly be classified in one or the other of two ways: those which should be settled by the people, and those which are best referred for final action to men trained in the subject-matter. There are some questions, however, which can not be put wholly in one or the other of these divisions. They are similar to those issues arising in the practise of law which are mixed questions of law and of fact, as, for example, the question of negligence. The court, when a case involving negligence is before it, decides what standards the law requires and provides certain positive rules which must be obeyed by a party in order for him to be in the exercise of due care. But within those rules there are a vast number of cases which may, or may not, amount to negligence in fact, according as the jury applies the test of what an ordinarily prudent person would, or would not, do under the circumstances.

So the tariff is a question both for congress and for experts. Under our federal constitution, as well as in accordance with the unwritten principles underlying our government, the power to lay duties is vested in congress. It can not be delegated to any other person or body whatsoever. Obtaining the evidence and finding the facts so that the duty can be intelligently levied, falls within the province of experts. It is for congress to say whether a tariff should be designed primarily for protection or primarily for revenue, and to lay duties accordingly. It has no power under the constitution, and ought to have none, to frame a tariff simply for the purpose of allowing certain persons to obtain an excessive profit. Such a tariff has been called a

tariff for profit. No reasonable person would contemplate the deliberate formation of such a tariff. It has doubtless been brought about as a result of certain schedules, but was presumably unintended by the framers. It is here that legislative machinery breaks down and requires the aid of experts to furnish the foundation for intelligent action. It is conceded that congressmen have no time, even if they have the capacity and inclination, to find out and properly correlate all the intricate items of supply and demand; weigh the variations of cost of production here and abroad, and finally to estimate the relative amount of protection and revenue, which will be yielded according as the duty is more or less. A schedule which produces a large revenue may not be protective and one which is protective may produce no revenue at all. But between these extremes are numberless shifting conditions where the amounts of protection and revenue vary as the duty is higher or lower.

Previous to about a year ago these reasons did not appear to congress sufficient to justify the appointment of a permanent governmental agency to inquire and find out in regard to this subject. But the agitation surrounding the framing of the Payne tariff bill was such that congress in August, 1909, passed a law which recognizes the need of such a board. Merchants and manufacturers throughout the country were emphatic in their demand for it. The great body of manufacturers had begun to realize that their foreign as well as domestic trade was seriously damaged or ruined, for the benefit of a few industries, which were making an excessive profit.

The popular branch of congress did not at first regard this agitation as of enough importance to warrant the passage of any law concerning it. In the senate, however, the finance committee were convinced of its sincerity. Several bills for a tariff commission had been introduced. Those proposing that such a commission should have power to fix rates, even within certain limits to be prescribed by congress, overstepped the domain of a commission for the reasons already stated. Others were within the proper field. On July 3, 1909, while the Payne bill was before the senate, the finance committee reported an amendment which provided for maximum and minimum rates. The general duties in the bill were to constitute the minimum tariff, and the amendment provided that from and after March 31, 1910, there should be added to the general duties a further one of 25 per cent. ad valorem, which was to constitute the maximum rate. It was further provided that, whenever after March 31, 1910, and so long thereafter as the president shall be satisfied that any foreign country imposes no discriminations or restrictions, against the United States, either by way of rates, regulations, charges, exactions or in any other manner, directly or indirectly, upon the importation of the products

of the United States, and that such foreign country pays no export bounty or imposes no export duty or prohibition upon the export of any article to the United States, which unduly discriminates against the United States or the products thereof, and that such foreign country accords to the products of the United States reciprocal and equivalent treatment, thereupon and thereafter, upon proclamation to this effect by the president, all articles from such country shall be admitted under the terms of the minimum tariff; that is, without the addition of the 25 per cent. ad valorem. The proclamation may extend to the whole of any foreign country or may be confined to, or exclude from its effect, any dependency, colony or other political subdivision, having authority to adopt and enforce legislation, or to impose restrictions or regulations, or to grant concessions, upon the exportation or importation of articles which are, or may be, imported into the United States.

It is further provided that whenever the president shall be satisfied that the conditions which led to the issuance of the proclamation no longer exist, he shall issue a proclamation to this effect, and ninety days thereafter the provisions of the maximum tariff shall be applicable to all productions of such country, whether imported directly or otherwise into the United States.

Then the amendment in the senate closed with this important clause:

To secure information to assist the president in the discharge of his duties imposed upon him by this section, and information which shall be useful to congress in tariff legislation, and to the officers of the government in the administration of the customs laws, the president is hereby authorized to employ such persons as may be required to make thorough investigations and examinations into the production, commerce and trade of the United States and foreign countries and all conditions affecting the same.

This amendment passed the senate and went with the rest of the senate bill to the committee of conference of the senate and house. The provision in regard to the maximum and minimum tariff board clause was cut down and made to read as follows:

To secure information to assist the president in the discharge of the duties imposed upon him by this section, and the officers of the government in the administration of the customs laws, the president is hereby authorized to employ such persons as may be required.

In this form it was finally passed by both houses of congress, signed by the president and is now the law.

What are the powers of this board under this act and what further authority, if any, ought to be given to it in order to make its usefulness as effective as possible?

The purposes of the board are twofold: (1) To secure information to assist the president in the discharge of the duties imposed upon him in the maximum and minimum section. (2) To secure information

to assist the officers of the government in the administration of the customs laws.

The scope of this language is much greater than appears on its face. The president in order to be satisfied of the existence of the facts, which are the basis of his proclamation, must have accurate information of the details which go to make up the presence or absence of discrimination on the part of every foreign country which does business with the United States. If the president is not satisfied, then the provision for this immense additional duty of 25 per cent. on the total value of the imported goods, remains in effect. It does not become operative by the action of the president, but continues in force by his omission or failure to act. It is evident that there will be enormous pressure from foreign governments as well as from our own importers to see that the president takes action if he has not already done so. If he is satisfied as to one or more foreign countries, and so proclaims in accordance with the law, the United States at once is in a position to demand fair and reciprocal treatment from the others. The fact that the products of any foreign country may be imported into the United States without the payment of 25 per cent. of their value, provided the president is satisfied that such foreign country makes no discrimination against the United States, is a strong argument, not to say leverage, to induce that foreign country to remove the discrimination and reap the benefit of trade with the United States. This would also be to the advantage of our own producers and manufacturers who desire a foreign market for their products.

A differential, or maximum and minimum, tariff, applicable to countries foreign to themselves, is in force in Argentine Republic, Austria-Hungary, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, Norway, Russia, Spain and Switzerland. A general tariff rate applicable to all foreign countries is in force in Mexico, Netherlands, Sweden, Turkey and the United Kingdom of Great Britain and Ireland. The United States had commercial agreements under section 3 of the tariff law of 1897, with Bulgaria, France, Germany, Great Britain, Italy, Netherlands, Portugal, Spain, Switzerland and Cuba. In France changes have been and are now under consideration, making the maximum rate to range from 25 per cent. to 100 per cent. above the minimum.

A brief consideration will disclose the necessity of the president's being correctly and accurately informed as to details in order to become satisfied that a foreign country accords to the products of the United States reciprocal and equivalent treatment. And he must not only be satisfied once, but he must continue to be satisfied in order to have the minimum duties remain. The act provides that so long as the president is satisfied, etc., the articles from such country shall be admitted

under the terms of the minimum tariff, and that whenever he shall be satisfied that the conditions which led to the issuance of the proclamation no longer exist, he shall issue a proclamation to this effect and ninety days thereafter the provisions of the maximum tariff shall be applicable to all productions of such country whether imported directly or otherwise into the United States.

These duties thus cast upon the president require him to keep in constant touch with the situation, not only of the treatment which our products receive when exported to foreign countries, but also as to the action of such foreign country in respect to export bounties, duties and prohibitions upon the export of any article to the United States, and its effect upon the United States and its products. There are many ways by which a country can indirectly discriminate against another country or its products. One way is to raise the valuation as appears on the invoice or bill of lading. This may result in the payment of a larger ad valorem duty or a higher specific one on account of a different classification. If such treatment is unfair, and is persisted in against the products of a particular country, and not pursued against those of other countries, the treatment is discriminatory. The value of the article exported then becomes of prime importance, for if the value stated on the invoice or bill of lading is less than it ought to be, perhaps so made with the intention of saving duty, then the foreign customs officers have an equitable right to raise the valuation to a proper and reasonable amount, and such action on their part, provided they do the same with the products of all other countries, is fair and just. In order for the president to know in regard to this, he must have accurate knowledge of the cost of production of all articles exported from this country, and as any article made in the United States is likely at any time to be exported, he should also have knowledge of its cost, etc., so as to be ready to act, when the occasion arises, as provided by the act of congress. Some articles are now exported from this country at valuations less than they are sold here. Such practise is not contrary to the law of the United States, but it is contrary to the law of foreign countries to value articles for the purpose of customs lower than they are worth. What they are worth depends to some extent upon their cost in the country where they are made.

The second branch of the tariff board's duties is to secure information to assist the officers of the government in the administration of the customs laws.

What has been said of importations into foreign countries applies to importations into our own. The proper administration of our customs laws requires on the part of the various officers of our government a clear insight into the value and cost of all articles imported. The acts of congress require the general appraiser and the boards of general

appraisers to "proceed by all reasonable ways and means in their power to ascertain, estimate and determine the dutiable value of the imported merchandise, and in so doing they may exercise both judicial and inquisitorial functions." This, however, only applies to articles which are subject to an ad valorem duty or to a duty based upon or regulated in some manner by the value thereof. In such cases the act distinctly provides that the duty shall be assessed upon the actual market value or wholesale price thereof, at the time of exportation to the United States, in the principal markets of the country whence the goods are exported; and that such actual market value shall be held to be the price at which such merchandise is freely offered for sale to all purchasers in said markets, in the usual wholesale quantities, and the price which the manufacturers or owners would have received, and was willing to receive, for such merchandise when sold in the ordinary course of trade in the usual wholesale quantities. In order to determine with any degree of accuracy, the appraisers, the board of appraisers, and on appeal the government's counsel, must be in possession of the facts in detail to properly know and present the government's side of the case. When one reflects that some 300 to 400 millions of dollars are expected to be annually collected as revenue from the tariff, one realizes that there are sure to be strong tendencies, acting on the exporters of foreign countries and the importers here, to keep the valuations down to the lowest possible sum. The importers are allowed to produce witnesses and try out their cases in very much the same manner as prevails in ordinary cases before the courts of justice, with the additional authority in the board of appraisers that they have inquisitorial powers.

The tariff board can clearly be of great assistance to our various customs officers if it should continually keep informed and have in its possession facts and figures relative to the cost of foreign products, as incidental to their true value and as indicative of the price which the foreign manufacturer or owner would have received and was willing to receive, when sold in the ordinary course of trade, in the usual wholesale quantities, in the principal markets of the country, whence the goods may be exported. Such assistance would be increased when the publications of the tariff board by virtue of their accuracy, completeness and truth come to be regarded as authoritative and are accepted as such both here and in foreign countries. A condition like this would lead to better trade relations between this country and the other powers of the world.

The president has repeatedly stated that he will construe the act as empowering the board to find out the facts at home and abroad so as to assist him in his administration of the maximum and minimum section, and to assist in the administration of the customs laws in general by the officers of the government. With this end in view he has directed

the board to secure information as to the cost of production in this country of all goods affected by the tariff law, and the cost of their production in foreign countries. Two members of the board, Professor Emery, its chairman, and Mr. Reynolds, have already visited Europe in obedience to the president's orders. Professor Emery has recently returned for consultation, leaving Mr. Reynolds abroad pursuing the work there.

The findings and publications of the board can not hereafter fail to reach congress either directly or by a presidential message, or otherwise, and in matters of tariff legislation should expedite hearings, and furnish solid foundation for intelligent tariff schedules.

In determining the construction to be put upon the language of a legislative act, the debates at the time of its consideration and passage are regarded as important factors in discovering the intention of the legislature as to its scope and meaning.

Senator Aldrich, of Rhode Island, the chairman of the finance committee, introduced the amendment in the senate. Senator LaFollette, of Wisconsin, who was notoriously in favor of a tariff commission, charged that the provisions were purposely such as to render any action by the proposed board of little, if any, value in future tariff legislation, and that no adequate appropriation would be made. Whereupon Senator Aldrich spoke as follows:

The duties of the commission, the parties to be named by the president, are defined in this act. They will also be defined by the president. So far as the appropriations are concerned, they will undoubtedly be made. This provision was put into the bill in good faith. It was agreed to by the senator from Indiana (Senator Beveridge) who aided in the preparation of it, and it covers all the suggestions and the requirements of the various organizations that have been asking us to provide for the appointment of a commission of this kind.

On the other hand, Senator Hale, of Maine, remarked:

I do not understand the provisions in any way constitute a tariff commission. . . . If I believed that the provisions of the bill would do anything more than allow the president to appoint experts that might from time to time report, and, if necessary, be sent to congress by the president, and that it would be a commission such as the senator wants, I would not vote for the proposition.

Later Senator Aldrich said:

This is not intended to be a partisan or non-partisan commission. It is intended to assist the president in carrying out the work that is assigned to him by the provisions of this section. It is also intended that they shall examine all questions pertaining to tariff matters and the products of foreign countries, so that they may have expert knowledge as to discriminations. For that purpose they will need to be acquainted with industrial conditions in this country and in other countries.

Whereupon Senator Bacon, of Georgia, interrupted and said:

If the senator will pardon me a moment I would like to draw his attention to the fact that the amendment proposes that these appointees—whatever name

may be properly given to them—shall not only gather information for the benefit of the president in determining what shall be done under the powers given to him under the amendment, but shall gather information which shall be useful to congress in tariff legislation.

Whereupon Senator Aldrich replied, "Unquestionably." Senator Bacon dwelt further upon the subject and inquired of the senator from Rhode Island if he heard him, whereupon Senator Aldrich answered that he did. And Senator Aldrich further stated:

I think the senator will agree with me, even from that standpoint, that this information ought not to be gathered by men with a partisan bias. I can imagine nothing which would be more detrimental to the purposes which we have in view than a partisan commission sent out to gather information with reference to one political view or one economic view or another. I think it would destroy the usefulness and the purpose of this commission, or whatever you please to call it.

This occurred before the clause was changed in conference between the two houses of congress. When the clause came back in the form in which it was finally passed, it was the subject of a long debate in the senate.

Several senators, among others, Senator Newlands, of Nevada, called attention to the bill as it had passed the senate and then inquired of the chairman of the finance committee, Senator Aldrich, how the change came to be made. Senator Aldrich said that the house conferees objected *in toto* to it. He said:

The inclusion of the words was a compromise between the two houses. I will say to the senator from Nevada, of course with due deference to his judgment to the contrary, that the provision contained in the bill itself is even broader than it was in the senate, in my judgment. It allows the president to employ whomever he pleases without limit and to assign such duties to them as he sees fit within the limitation of the maximum and minimum provision, and to assist the customs officers in the discharge of their duties. Now these two purposes, especially the latter, cover every conceivable question that is covered by tariff legislation.

Whereupon Senator Newlands inquired whether the bill as it came from the conferees would warrant the president in appointing men who will inquire into and ascertain the difference in the cost of production at home and abroad, of the articles covered by the tariff. Whereupon Senator Aldrich answered:

Unquestionably it will, for the reason . . . the home valuation as well as the foreign valuation of goods is a matter which has to be determined by the customs officers, and that involves, of course, all collateral questions. I have no doubt myself that the provision as it now stands is, as I have already stated, even broader than the provision which passed the senate.

Senator Beveridge then asked Senator Aldrich if he did not differ from Senator Hale when the deficiency appropriation bill was being passed, and Senator Newlands said he was about to ask the same question, to which Senator Aldrich answered that he was not present

when the senator from Maine (Senator Hale) made a statement on that subject, "but," he said, "I am stating my own views, which are clearly carried out in my judgment by the language used in the act." Senator Newlands then remarked that he was much gratified to receive the assurance from the senator from Rhode Island and that it did credit to that senator's good faith and to his maintenance of his obligation to the senate.

Senator Aldrich then said:

I think I can say, without betraying the confidence of the president, that the views which I entertain are also the views entertained by the president of the United States.

This language of Senator Aldrich, who was chairman of the committee which had charge of the bill in the senate, and who was one of the conferees, was frequently quoted afterwards in the debate, particularly by Senator Beveridge, who was and is in favor of a tariff board with sufficient powers to make itself useful, and the bill was passed with that understanding in the senate. In the house after the conference, the debate was general and nothing contrary to the senate's intention occurred.

For the work of the board the present congress at its last session appropriated two hundred and fifty thousand dollars in the last sundry civil appropriation bill, which contains the following:

To enable the president to secure information to assist him in the discharge of the duties imposed upon him by section 2 of the act entitled "An act to provide revenues, equalize the duties, and encourage the industries of the United States, and for other purposes," approved August 5, 1909, and the officers of the government in administering the customs laws, including such investigations of the cost of production of commodities, covering cost of material, fabrication and every other element of such cost of production, as are authorized by said act, and including the employment of such persons as may be required for those purposes, and to enable him to do any and all things in connection therewith authorized by law, $250,000.

This new provision, while it refers for authority to the old act, is indicative of the construction thereof which has been hereinbefore stated.

The limitations of the tariff board are in the absence of ways and means of obtaining evidence in regard to the facts about which it is to secure information. It has no power to summon witnesses or compel the production of books or papers. If, however, the board shall have access to the facts in the possession of other governmental agencies, such as the consular and secret revenue service, the bureau of corporations in the department of commerce and labor, and of the officers of the government, who have charge of the collection of the corporation tax (if that is held to be constitutional), the ways and means which are otherwise lacking will be largely provided for. Under the law the president can direct all other governmental agencies to aid

the board and to permit it and its agents, to examine all papers, statistics, evidence, files, etc., in their custody. Such a course would commend itself on the ground of dispensing with duplication of labor and therefore saving expense to the government.

From these considerations it will appear that the scope of the act providing for the tariff board is sufficiently broad for present purposes, and the only action from congress needed is to provide adequate appropriations. To bring about this result, the continued interest, on the part of all persons who desire intelligent tariff laws, and their reasonable and honest administration, is required.

The board can not assume or be given the congressional prerogative of making the rates any more than the president can make the rates under this law. He can proclaim the event, upon the happening of which congress says the different rates shall go into effect. The Supreme Court so held in Field *vs.* Clark, 143 U. S., 692.

As time shows the necessity, and the work of the board commends itself, or requires it, changes doubtless will be needed in the law; notably some provision authorizing the tariff board to present the facts directly to the ways and means committee, whenever any tariff legislation is before congress. The board should furnish data and memoranda with verifying witnesses, who could be examined by the ways and means committee and by parties interested. In this way the whole people of the country would be represented before the committee in a substantial manner, where now they are practically unrepresented so far as the presentation of the case by witnesses and counsel is concerned. As a check upon the accuracy of the work of the board, parties interested should have the privilege of cross-examination, and also the right to bring before the congressional committee, which is independent of the board and of the department to which it belongs, experts of their own; these experts in turn to be subject to cross-examination by counsel representing the tariff board.

Congress has taken a great step towards the scientific disentanglement of the tariff subject, and towards the consequent enlargement of our foreign trade, and it only remains for the people of the United States to give their cordial support to the board in every reasonable endeavor it makes to obtain the facts which are at the basis of the solution of this intricate and vexing question. Thus will future congresses be able and willing to deal with the tariff in an equitable way.

A SUPREME COURT OF SCIENCE

By Professor J. PEASE NORTON
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IN the government of the nations, political parties and elections are the slow methods by which national policies are determined. Movements are started in response to conditions which seem to require legislation. Gradually, these movements are combined within the political parties in the platforms of which the issues are suitably expressed. If the interests are sufficient in the combination rapidly to propagate the platform, the party comes into power. When in power, by agreement in the congress or the legislature, laws are placed upon the statute books. These laws are passed by the party after careful consideration by the committees having these matters in charge.

In all this, there is a great waste of effort, because the results are modified by small minorities who are able at tactical points to bring to bear immense pressure on individuals. In this manner, the will of the majority of the people, which is the vague desire to remedy wrongs or to perfect a better method of conserving the prosperity and of increasing the national comfort, is thwarted. As a result the laws in some instances are a generation out of date. When the situation becomes intolerable, a too radical reaction is inevitable, and, in the end, the peaceful, orderly development of a people is impaired to the great loss of the whole nation.

Now, many of the issues which divide the country, in fact all countries, into opposing camps are scientific in their nature. Long campaigns must be fought to decide policies which are capable of easy solution, if only an impartial court existed before which such issues could be tried. Just as technical questions require technical experts, technical issues require a technical court. The administration at Washington favors the establishment of a court of commerce. Why should there not be a court of science to determine questions of scientific truth, the application and the feasibility of issues based on scientific knowledge?

Let us take an example. We find there exists a powerful society with state branches and paid agents for carrying on a campaign against vaccination, which is a scientific issue. The conditions are substantially these. Many states have compulsory vaccination laws. School children are being vaccinated on a wholesale scale as a precaution

against a danger which is probably little greater than the danger of being struck by lightning. How these laws came upon the statute, books, anti-vaccinationists explain by citing illustrations of activity on the part of the lobbyists maintained by the virus makers. They say school children are being vaccinated to sell virus. Now this movement is costing a large amount of money. This society feels that pressure must be brought to bear on legislatures throughout the United States in order to modify the laws. These laws rest on the implied scientific knowledge that vaccination is efficacious in a degree sufficient to justify a wholesale application of the remedy to the people, and that the danger of smallpox is sufficient to justify the application and that no other remedy is available against the danger so desirable as the remedy called for by the compulsory vaccination laws.

We should remember that these laws were made by legislatures of states, and that the legislatures passed the laws on the recommendations of committees composed of men of average intelligence who could not have had scientific knowledge of the issue without expert testimony. Now, such laws as these are apt to be passed without careful consideration, and it is doubtful whether this scientific knowledge has been sufficiently determined. We must as scientists differentiate between traditional scientific knowledge and scientific knowledge based on evidence which is conclusive enough to stand the test of a court of science.

Who would not like to see a case brought against the custom of vaccination in a supreme court of science before a grand jury consisting of twenty-five scientific and engineering experts drawn from the various walks of the scientific professions. Let such a case be argued by legal counsel and all evidence introduced by experts on both sides be subject to cross examination. In a comparatively short time and at a relatively small expense, society would be in a position to know whether in the judgment of a jury of impartial experts trained to the weighing of real scientific facts, the evidence justified the position that vaccination is clearly efficacious to a degree sufficient to justify a wholesale vaccination of little children in the schools throughout the country, and even if efficacious in such degree whether the danger of smallpox is sufficient to justify the application of the precaution, and further that no other remedy, less dangerous and less costly or more efficacious exists, such, for instance, as effective quarantine, which is considered by the anti-vaccinationists to be the more desirable. In such a way, this question, which has disturbed us for forty years or more and will furnish a running agitation for a decade or two longer in all probability, could be settled once for all with dispatch.

Before such a court of science, all interested parties could appear with experts; on the one side the virus manufacturers, the physicians

and those public-health officials who believe in the practise, and on the other side the taxpayers and the people represented by the government. The findings of such a court would be of great service to lawmakers and other courts of the land. For the virus makers and the physicians are not the only interests which are interested in vaccinating the people for something. The laws which have been passed are countless in number. If all laws could be declared void which were based on implied scientific knowledge which is false or not proven, a vast number of undesirable laws could be economically erased. Most laws passed for grafting purposes would fail in a court of science.

When we consider how many are the issues which disturb the country and which cause the expenditure of millions of dollars in agitation to no good result, and, at the same time, the ease with which many of the disputed scientific issues could be settled, the desirability of a court of science with proper rules of procedure is apparent. It is amazing to consider the struggles which occur, the endless substantiations of a position for or against an "ism" by arrays of opinions, the violent charge and counter charge of factions and parties, all of which might be settled by a court of science. All that is required is a relatively small expenditure for the collection and the presentation of the evidence.

When the costly agitations of the past are analyzed, such as a tariff on any commodity for the purpose of "protection," "silver sixteen to one," "vaccination compulsory," "vaccination voluntary without quarantine," as in Minnesota, "conservation"—in short, the countless "isms," why should they not be settled in a court? When such "isms" become popular enough to become the basis or the cause of legislation which means that the "isms" are to be forced on others than on believers, then it would seem that those who favor the "ism" should be placed on trial before a scientific jury in the supreme court of science. Many issues may be narrowed down to the determination of a few simple questions which may be answered by a jury of intelligent men. In what degree is the "ism" efficacious and does the degree of truth found justify the application? On the side of the conditions to be remedied, are the facts grievous enough to justify a general remedy? Is there no other remedy more efficacious?

Should the supreme court of science decide after a fair trial that compulsory vaccination was indefensible on the evidence, and that the practise of vivisection was defensible and desirable within proper limits, two costly "movements" would be ended with these findings. We may rest assured, if the supreme court of science impartially decided on the evidence in accordance with a regular procedure, that the truth would prevail with far greater dispatch than under the present system of countless "movements." Many of these associations have an

income just about sufficient to make the "wheels go round" in the office and the surplus available wherewith to grind grain is a very small fraction of the funds required to keep the wheels in motion. Under the billing system for small dues from hundreds of members and new membership campaigns, often seventy-five to one hundred per cent. of the funds are consumed. Instead of wasting so much capital in beating the tom-toms and in asserting and defending from attack alleged scientific knowledge, one quarter of the energy would be sufficient to settle these scientific questions for all time if expended in bringing the evidence suitably before an impartial scientific tribunal whose decision would command respect. With the same decision, much agitation and annoyance would be saved our good people, who are wearing themselves out trying to form intelligent opinions on all kinds of technical questions without proper evidence presented on either side.

THE MORAL EQUIVALENT OF WAR[1]

By WILLIAM JAMES

THE war against war is going to be no holiday excursion or camping party. The military feelings are too deeply grounded to abdicate their place among our ideals until better substitutes are offered than the glory and shame that come to nations as well as to individuals from the ups and downs of politics and the vicissitudes of trade. There is something highly paradoxical in the modern man's relation to war. Ask all our millions, north and south, whether they would vote now (were such a thing possible) to have our war for the Union expunged from history, and the record of a peaceful transition to the present time substituted for that of its marches and battles, and probably hardly a handful of eccentrics would say yes. Those ancestors, those efforts, those memories and legends, are the most ideal part of what we now own together, a sacred spiritual possession worth more than all the blood poured out. Yet ask those same people whether they would be willing in cold blood to start another civil war now to gain another similar possession, and not one man or woman would vote for the proposition. In modern eyes, precious though wars may be, they must not be waged solely for the sake of the ideal harvest. Only when forced upon one, only when an enemy's injustice leaves us no alternative, is war now thought permissible.

It was not thus in ancient times. The earlier men were hunting men, and to hunt a neighboring tribe, kill the males, loot the villages and possess the females, was the most profitable, as well as the most exciting, way of living. Thus were the more martial tribes selected, and in chiefs and peoples a pure pugnacity and love of glory came to mingle with the more fundamental appetite for plunder.

Modern war is so expensive that we feel trade to be a better avenue to plunder; but modern man inherits all the innate pugnacity and all the love of glory of his ancestors. Showing war's irrationality and horror is of no effect upon him. The horrors make the fascination. War is the *strong* life; it is life *in extremis;* war-taxes are the only ones men never hesitate to pay; as the budgets of all nations show us.

History is a bath of blood. The Iliad is one long recital of how Diomedes and Ajax, Sarpedon and Hector *killed.* No detail of the

[1] This article, published last February by the American Association for International Conciliation, is here reproduced as a tribute to the memory of William James. It was written at the suggestion of the editor of THE POPULAR SCIENCE MONTHLY.

wounds they made is spared us, and the Greek mind fed upon the story. Greek history is a panorama of jingoism and imperialism—war for war's sake, all the citizens being warriors. It is horrible reading, because of the irrationality of it all—save for the purpose of making "history"—and the history is that of the utter ruin of a civilization in intellectual respects perhaps the highest the earth has ever seen.

Those wars were purely piratical. Pride, gold, women, slaves, excitement, were their only motives. In the Peloponnesian war, for example, the Athenians ask the inhabitants of Melos (the island where the "Venus of Milo" was found), hitherto neutral, to own their lordship. The envoys meet, and hold a debate which Thucydides gives in full, and which, for sweet reasonableness of form, would have satisfied Matthew Arnold. "The powerful exact what they can," said the Athenians, "and the weak grant what they must." When the Meleans say that sooner than be slaves they will appeal to the gods, the Athenians reply: "Of the gods we believe and of men we know that, by a law of their nature, wherever they can rule they will. This law was not made by us, and we are not the first to have acted upon it; we did but inherit it, and we know that you and all mankind, if you were as strong as we are, would do as we do. So much for the gods; we have told you why we expect to stand as high in their good opinion as you." Well, the Meleans still refused, and their town was taken. "The Athenians," Thucydides quietly says, "thereupon put to death all who were of military age and made slaves of the women and children. They then colonized the island, sending thither five hundred settlers of their own."

Alexander's career was piracy pure and simple, nothing but an orgy of power and plunder, made romantic by the character of the hero. There was no rational principle in it, and the moment he died his generals and governors attacked one another. The cruelty of those times is incredible. When Rome finally conquered Greece, Paulus Æmilius was told by the Roman Senate to reward his soldiers for their toil by "giving" them the old kingdom of Epirus. They sacked seventy cities and carried off a hundred and fifty thousand inhabitants as slaves. How many they killed I know not; but in Etolia they killed all the senators, five hundred and fifty in number. Brutus was "the noblest Roman of them all," but to reanimate his soldiers on the eve of Philippi he similarly promises to give them the cities of Sparta and Thessalonica to ravage, if they win the fight.

Such was the gory nurse that trained societies to cohesiveness. We inherit the warlike type; and for most of the capacities of heroism that the human race is full of we have to thank this cruel history. Dead men tell no tales, and if there were any tribes of other type than this they have left no survivors. Our ancestors have bred pugnacity into our bone and marrow, and thousands of years of peace won't breed it

out of us. The popular imagination fairly fattens on the thought of wars. Let public opinion once reach a certain fighting pitch, and no ruler can withstand it. In the Boer war both governments began with bluff, but couldn't stay there, the military tension was too much for them. In 1898 our people had read the word WAR in letters three inches high for three months in every newspaper. The pliant politician McKinley was swept away by their eagerness, and our squalid war with Spain became a necessity.

At the present day, civilized opinion is a curious mental mixture. The military instincts and ideals are as strong as ever, but are confronted by reflective criticisms which sorely curb their ancient freedom. Innumerable writers are showing up the bestial side of military service. Pure loot and mastery seem no longer morally avowable motives, and pretexts must be found for attributing them solely to the enemy. England and we, our army and navy authorities repeat without ceasing, arm solely for "peace," Germany and Japan it is who are bent on loot and glory. "Peace" in military mouths to-day is a synonym for "war expected." The word has become a pure provocative, and no government wishing peace sincerely should allow it ever to be printed in a newspaper. Every up-to-date dictionary should say that "peace" and "war" mean the same thing, now *in posse,* now *in actu.* It may even reasonably be said that the intensely sharp competitive *preparation* for war by the nations *is the real war,* permanent, unceasing; and that the battles are only a sort of public verification of the mastery gained during the "peace"-interval.

It is plain that on this subject civilized man has developed a sort of double personality. If we take European nations, no legitimate interest of any one of them would seem to justify the tremendous destructions which a war to compass it would necessarily entail. It would seem as though common sense and reason ought to find a way to reach agreement in every conflict of honest interests. I myself think it our bounden duty to believe in such international rationality as possible. But, as things stand, I see how desperately hard it is to bring the peace-party and the war-party together, and I believe that the difficulty is due to certain deficiences in the program of pacificism which set the militarist imagination strongly, and to a certain extent justifiably, against it. In the whole discussion both sides are on imaginative and sentimental ground. It is but one utopia against another, and everything one says must be abstract and hypothetical. Subject to this criticism and caution, I will try to characterize in abstract strokes the opposite imaginative forces, and point out what to my own very fallible mind seems the best utopian hypothesis, the most promising line of conciliation.

In my remarks, pacificist though I am, I will refuse to speak of the bestial side of the war-régime (already done justice to by many

writers) and consider only the higher aspects of militaristic sentiment. Patriotism no one thinks discreditable; nor does any one deny that war is the romance of history. But inordinate ambitions are the soul of every patriotism, and the possibility of violent death the soul of all romance. The militarily patriotic and romantic-minded everywhere, and especially the professional military class, refuse to admit for a moment that war may be a transitory phenomenon in social evolution. The notion of a sheep's paradise like that revolts, they say, our higher imagination. Where then would be the steeps of life? If war had ever stopped, we should have to re-invent it, on this view, to redeem life from flat degeneration.

Reflective apologists for war at the present day all take it religiously. It is a sort of sacrament. Its profits are to the vanquished as well as to the victor; and quite apart from any question of profit, it is an absolute good, we are told, for it is human nature at its highest dynamic. Its "horrors" are a cheap price to pay for rescue from the only alternative supposed, of a world of clerks and teachers, of co-education and zoophily, of "consumer's leagues" and "associated charities," of industrialism unlimited, and feminism unabashed. No scorn, no hardness, no valor any more! Fie upon such a cattleyard of a planet!

So far as the central essence of this feeling goes, no healthy minded person, it seems to me, can help to some degree partaking of it. Militarism is the great preserver of our ideals of hardihood, and human life with no use for hardihood would be contemptible. Without risks or prizes for the darer, history would be insipid indeed; and there is a type of military character which every one feels that the race should never cease to breed, for every one is sensitive to its superiority. The duty is incumbent on mankind, of keeping military characters in stock —of keeping them, if not for use, then as ends in themselves and as pure pieces of perfection—so that Roosevelt's weaklings and molly-coddles may not end by making everything else disappear from the face of nature.

This natural sort of feeling forms, I think, the innermost soul of army-writings. Without any exception known to me, militarist authors take a highly mystical view of their subject, and regard war as a biological or sociological necessity, uncontrolled by ordinary psychological checks and motives. When the time of development is ripe the war must come, reason or no reason, for the justifications pleaded are invariably fictitious. War is, in short, a permanent human *obligation*. General Homer Lea, in his recent book "The Valor of Ignorance," plants himself squarely on this ground. Readiness for war is for him the essence of nationality, and ability in it the supreme measure of the health of nations.

Nations, General Lea says, are never stationary—they must necessarily expand or shrink, according to their vitality or decrepitude. Japan now is culminating; and by the fatal law in question it is impossible that her statesmen should not long since have entered, with extraordinary foresight, upon a vast policy of conquest—the game in which the first moves were her wars with China and Russia and her treaty with England, and of which the final objective is the capture of the Philippines, the Hawaiian Islands, Alaska and the whole of our coast west of the Sierra passes. This will give Japan what her ineluctable vocation as a state absolutely forces her to claim, the possession of the entire Pacific Ocean; and to oppose these deep designs we Americans have, according to our author, nothing but our conceit, our ignorance, our commercialism, our corruption, and our feminism. General Lea makes a minute technical comparison of the military strength which we at present could oppose to the strength of Japan, and concludes that the islands, Alaska, Oregon and southern California, would fall almost without resistance, that San Francisco must surrender in a fortnight to a Japanese investment, that in three or four months the war would be over, and our republic, unable to regain what it had heedlessly neglected to protect sufficiently, would then "disintegrate," until perhaps some Cæsar should arise to weld us again into a nation.

A dismal forecast indeed! Yet not unplausible, if the mentality of Japan's statesmen be of the Cæsarian type of which history shows so many examples, and which is all that General Lea seems able to imagine. But there is no reason to think that women can no longer be the mothers of Napoleonic or Alexandrian characters; and if these come in Japan and find their opportunity, just such surprises as "The Valor of Ignorance" paints may lurk in ambush for us. Ignorant as we still are of the innermost recesses of Japanese mentality, we may be foolhardy to disregard such possibilities.

Other militarists are more complex and more moral in their considerations. The "Philosophie des Krieges," by S. R. Steinmetz is a good example. War, according to this author, is an ordeal instituted by God, who weighs the nations in its balance. It is the essential form of the state, and the only function in which peoples can employ all their powers at once and convergently. No victory is possible save as the resultant of a totality of virtues, no defeat for which some vice or weakness is not responsible. Fidelity, cohesiveness, tenacity, heroism, conscience, education, inventiveness, economy, wealth, physical health and vigor—there isn't a moral or intellectual point of superiority that doesn't tell, when God holds his assizes and hurls the peoples upon one another. *Die Weltgeschichte ist das Weltgericht;* and Dr. Steinmetz

does not believe that in the long run chance and luck play any part in apportioning the issues.

The virtues that prevail, it must be noted, are virtues anyhow, superiorities that count in peaceful as well as in military competition; but the strain on them, being infinitely intenser in the latter case, makes war infinitely more searching as a trial. No ordeal is comparable to its winnowings. Its dread hammer is the welder of men into cohesive states, and nowhere but in such states can human nature adequately develop its capacity. The only alternative is "degeneration."

Dr. Steinmetz is a conscientious thinker, and his book, short as it is, takes much into account. Its upshot can, it seems to me, be summed up in Simon Patten's word, that mankind was nursed in pain and fear, and that the transition to a "pleasure-economy" may be fatal to a being wielding no powers of defense against its disintegrative influences. If we speak of the *fear of emancipation from the fear-régime,* we put the whole situation into a single phrase; fear regarding ourselves now taking the place of the ancient fear of the enemy.

Turn the fear over as I will in my mind, it all seems to lead back to two unwillingnesses of the imagination, one esthetic, and the other moral: unwillingness, first to envisage a future in which army-life, with its many elements of charm, shall be forever impossible, and in which the destinies of peoples shall nevermore be decided quickly, thrillingly and tragically, by force, but only gradually and insipidly by "evolution"; and, secondly, unwillingness to see the supreme theater of human strenuousness closed, and the splendid military aptitudes of men doomed to keep always in a state of latency and never show themselves in action. These insistent unwillingnesses, no less than other esthetic and ethical insistencies have, it seems to me, to be listened to and respected. One can not meet them effectively by mere counter-insistency on war's expensiveness and horror. The horror makes the thrill; and when the question is of getting the extremest and supremest out of human nature, talk of expense sounds ignominious. The weakness of so much merely negative criticism is evident—pacificism makes no converts from the military party. The military party denies neither the bestiality nor the horror, nor the expense; it only says that these things tell but half the story. It only says that war is *worth* them; that, taking human nature as a whole, its wars are its best protection against its weaker and more cowardly self, and that mankind can not *afford* to adopt a peace-economy.

Pacificists ought to enter more deeply into the esthetical and ethical point of view of their opponents. Do that first in any controversy, says J. J. Chapman, *then move the point,* and your opponent will follow. So long as anti-militarists propose no substitute for war's disciplinary function, no *moral equivalent* of war, analogous, as one might say, to

the mechanical equivalent of heat, so long they fail to realize the full inwardness of the situation. And as a rule they do fail. The duties, penalties and sanctions pictured in the utopias they paint are all too weak and tame to touch the military-minded. Tolstoy's pacificism is the only exception to this rule, for it is profoundly pessimistic as regards all this world's values, and makes the fear of the Lord furnish the moral spur provided elsewhere by the fear of the enemy. But our socialistic peace-advocates all believe absolutely in this world's values; and instead of the fear of the Lord and the fear of the enemy, the only fear they reckon with is the fear of poverty if one be lazy. This weakness pervades all the socialistic literature with which I am acquainted. Even in Lowes Dickinson's exquisite dialogue,[2] high wages and short hours are the only forces invoked for overcoming man's distaste for repulsive kinds of labor. Meanwhile men at large still live as they always have lived, under a pain-and-fear economy—for those of us who lived in an ease-economy are but an island in the stormy ocean—and the whole atmosphere of present-day utopian literature tastes mawkish and dishwatery to people who still keep a sense for life's more bitter flavors. It suggests, in truth, ubiquitous inferiority.

Inferiority is always with us, and merciless scorn of it is the keynote of the military temper. "Dogs, would you live forever?" shouted Frederick the Great. "Yes," say our utopians, "let us live forever, and raise our level gradually." The best thing about our "inferiors" to-day is that they are as tough as nails, and physically and morally almost as insensitive. Utopianism would see them soft and squeamish, while militarism would keep their callousness, but transfigure it into a meritorious characteristic, needed by "the service," and redeemed by that from the suspicion of inferiority. All the qualities of a man acquire dignity when he knows that the service of the collectivity that owns him needs them. If proud of the collectivity, his own pride rises in proportion. No collectivity is like an army for nourishing such pride; but it has to be confessed that the only sentiment which the image of pacific cosmopolitan industrialism is capable of arousing in countless worthy breasts is shame at the idea of belonging to *such* a collectivity. It is obvious that the United States of America as they exist to-day impress a mind like General Lea's as so much human blubber. Where is the sharpness and precipitousness, the contempt for life, whether one's own, or another's? Where is the savage "yes" and "no," the unconditional duty? Where is the conscription? Where is the blood-tax? Where is anything that one feels honored by belonging to?

Having said thus much in preparation, I will now confess my own utopia. I devoutly believe in the reign of peace and in the gradual

[2] "Justice and Liberty," New York, 1909.

advent of some sort of a socialistic equilibrium. The fatalistic view of the war-function is to me nonsense, for I know that war-making is due to definite motives and subject to prudential checks and reasonable criticisms, just like any other form of enterprise. And when whole nations are the armies, and the science of destruction vies in intellectual refinement with the sciences of production, I see that war becomes absurd and impossible from its own monstrosity. Extravagant ambitions will have to be replaced by reasonable claims, and nations must make common cause against them. I see no reason why all this should not apply to yellow as well as to white countries, and I look forward to a future when acts of war shall be formally outlawed as between civilized peoples.

All these beliefs of mine put me squarely into the anti-militarist party. But I do not believe that peace either ought to be or will be permanent on this globe, unless the states pacifically organized preserve some of the old elements of army-discipline. A permanently successful peace-economy can not be a simple pleasure-economy. In the more or less socialistic future towards which mankind seems drifting we must still subject ourselves collectively to those severities which answer to our real position upon this only partly hospitable globe. We must make new energies and hardihoods continue the manliness to which the military mind so faithfully clings. Martial virtues must be the enduring cement; intrepidity, contempt of softness, surrender of private interest, obedience to command, must still remain the rock upon which states are built—unless, indeed, we wish for dangerous reactions against commonwealths fit only for contempt, and liable to invite attack whenever a center of crystallization for military-minded enterprise gets formed anywhere in their neighborhood.

The war-party is assuredly right in affirming and reaffirming that the martial virtues, although originally gained by the race through war, are absolute and permanent human goods. Patriotic pride and ambition in their military form are, after all, only specifications of a more general competitive passion. They are its first form, but that is no reason for supposing them to be its last form. Men now are proud of belonging to a conquering nation, and without a murmur they lay down their persons and their wealth, if by so doing they may fend off subjection. But who can be sure that *other aspects of one's country* may not, with time and education and suggestion enough, come to be regarded with similarly effective feelings of pride and shame? Why should men not some day feel that it is worth a blood-tax to belong to a collectivity superior in *any* ideal respect? Why should they not blush with indignant shame if the community that owns them is vile in any way whatsoever? Individuals, daily more numerous, now feel this civic passion. It is only a question of blowing on the spark till the

whole population gets incandescent, and on the ruins of the old morals of military honor, a stable system of morals of civic honor builds itself up. What the whole community comes to believe in grasps the individual as in a vise. The war-function has grasped us so far; but constructive interests may some day seem no less imperative, and impose on the individual a hardly lighter burden.

Let me illustrate my idea more concretely. There is nothing to make one indignant in the mere fact that life is hard, that men should toil and suffer pain. The planetary conditions once for all are such, and we can stand it. But that so many men, by mere accidents of birth and opportunity, should have a life of *nothing else* but toil and pain and hardness and inferiority imposed upon them, should have *no* vacation, while others natively no more deserving never get any taste of this campaigning life at all—*this* is capable of arousing indignation in reflective minds. It may end by seeming shameful to all of us that some of us have nothing but campaigning, and others nothing but unmanly ease. If now—and this is my idea—there were, instead of military conscription a conscription of the whole youthful population to form for a certain number of years a part of the army enlisted against *nature,* the injustice would tend to be evened out, and numerous other goods to the commonwealth would follow. The military ideals of hardihood and discipline would be wrought into the growing fiber of the people; no one would remain blind as the luxurious classes now are blind, to man's real relations to the globe he lives on, and to the permanently sour and hard foundations of his higher life. To coal and iron mines, to freight trains, to fishing fleets in December, to dishwashing, clothes-washing and window-washing, to road-building and tunnel-making, to foundries and stoke-holes, and to the frames of skyscrapers, would our gilded youths be drafted off, according to their choice, to get the childishness knocked out of them, and to come back into society with healthier sympathies and soberer ideas. They would have paid their blood-tax, done their own part in the immemorial human warfare against nature, they would tread the earth more proudly, the women would value them more highly, they would be better fathers and teachers of the following generation.

Such a conscription, with the state of public opinion that would have required it, and the many moral fruits it would bear, would preserve in the midst of a pacific civilization the manly virtues which the military party is so afraid of seeing disappear in peace. We should get toughness without callousness, authority with as little criminal cruelty as possible, and painful work done cheerily because the duty is temporary, and threatens not, as now, to degrade the whole remainder of one's life. I spoke of the "moral equivalent" of war. So far, war has been the only force that can discipline a whole community, and until

an equivalent discipline is organized, I believe that war must have its way. But I have no serious doubt that the ordinary prides and shames of social man, once developed to a certain intensity, are capable of organizing such a moral equivalent as I have sketched, or some other just as effective for preserving manliness of type. It is but a question of time, of skillful propagandism, and of opinion-making men seizing historic opportunities.

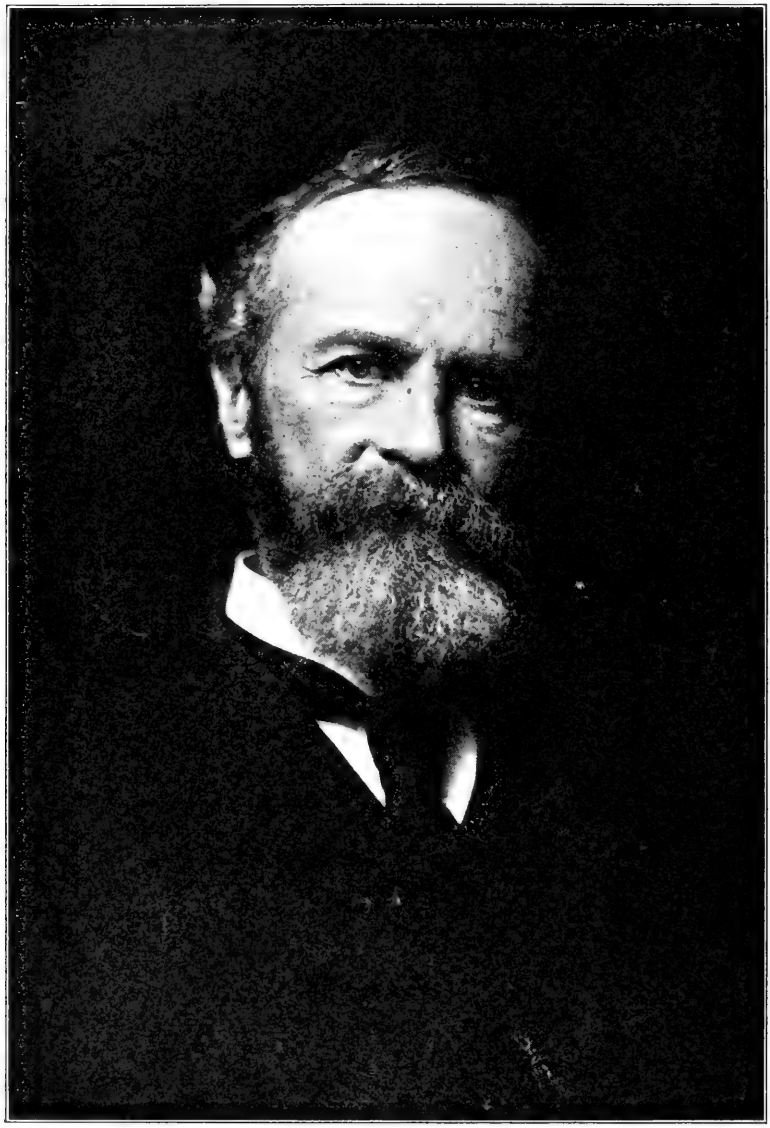
The martial type of character can be bred without war. Strenuous honor and disinterestedness abound elsewhere. Priests and medical men are in a fashion educated to it, and we should all feel some degree of it imperative if we were conscious of our work as an obligatory service to the state. We should be *owned,* as soldiers are by the army, and our pride would rise accordingly. We could be poor, then, without humiliation, as army officers now are. The only thing needed henceforward is to inflame the civic temper as past history has inflamed the military temper. H. G. Wells, as usual, sees the center of the situation. "In many ways," he says, "military organization is the most peaceful of activities. When the contemporary man steps from the street, of clamorous insincere advertisement, push, adulteration, underselling and intermittent employment, into the barrack-yard, he steps on to a higher social plane, into an atmosphere of service and cooperation and of infinitely more honorable emulations. Here at least men are not flung out of employment to degenerate because there is no immediate work for them to do. They are fed and drilled and trained for better services. Here at least a man is supposed to win promotion by self-forgetfulness, and not by self-seeking. And beside the feeble and irregular endowment of research by commercialism, its little short-sighted snatches at profit by innovation and scientific economy, see how remarkable is the steady and rapid development of method and appliances in naval and military affairs! Nothing is more striking than to compare the progress of civil conveniences which has been left almost entirely to the trader, to the progress in military apparatus during the last few decades. The house-appliances of to-day, for example, are little better than they were fifty years ago. A house of to-day is still almost as ill-ventilated, badly heated by wasteful fires, clumsily arranged and furnished as the house of 1858. Houses a couple of hundred years old are still satisfactory places of residence, so little have our standards risen. But the rifle or battleship of fifty years ago was beyond all comparison inferior to those we possess; in power, in speed, in convenience alike. No one has a use now for such superannuated things." [3]

Wells adds[4] that he thinks that the conceptions of order and discipline, the tradition of service and devotion, of physical fitness, un-

[3] "First and Last Things," 1908, p. 215.

[4] *Ibid.,* p. 226.

stinted exertion and universal responsibility, which universal military duty is now teaching European nations, will remain a permanent acquisition, when the last ammunition has been used in the fireworks that celebrate the final peace. I believe as he does. It would be simply preposterous if the only force that could work ideals of honor and standards of efficiency into English or American natures should be the fear of being killed by the Germans or the Japanese. Great indeed is fear; but it is not, as our military enthusiasts believe and try to make us believe, the only stimulus known for awakening the higher ranges of men's spiritual energy. The amount of alteration in public opinion which my utopia postulates is vastly less than the difference between the mentality of those black warriors who pursued Stanley's party on the Congo with their cannibal war-cry of "meat! meat" and that of the "general staff" of any civilized nation. History has seen the latter interval bridged over: the former one can be bridged over much more easily.



William James

THE PROGRESS OF SCIENCE

WILLIAM JAMES

Is there left to us in this land a man so great as William James? If the list of our leaders is scanned, men eminent in philosophy, science, art or letters, in education, law, politics or business, is there a single one to be placed beside him? He excelled in so many ways, in science, in philosophy, in letters, as a teacher, as a leader in good causes and lost causes, before all as a man—kind and generous beyond measure, of remarkable individuality and distinction.

The "Principles of Psychology," published in 1890, is a scientific and literary classic. No one can foretell whether it will be permanently in the group of philosophical masterpieces, beginning with the dialogues of Plato, but there is no contemporary American work and possibly no European work since the "Origin of Species," which has an equal chance.

Wilhelm Wundt and William James are the founders of psychology, a science which in a single generation has assumed a place coordinate with the other leading sciences. Both men—like their forerunners, Lotze and von Helmholtz—had an education in medicine and the natural sciences, with strong natural interests in philosophy and metaphysics. They established laboratories of psychology at about the same time, neither of them did experimental work of consequence, both prepared treatises which to a remarkable extent established the lines of development for a science. Wundt's "Physiologische Psychologie" is more systematic than James's "Principles of Psychology"; it is more of an encyclopedia. For that reason it could be brought out in various editions, corrected and enlarged. James's "Psychology" is more of a work of art, exhibiting the subject as he left it twenty years ago.

It is truly a remarkable book, combining physiology, pathological psychology, comparative psychology, experimental psychology, introspective psychology and philosophy into one whole which has dominated the science. The author is always accurate in his scientific material and clear in his statements, but frank in his criticism and daring in his conclusions. His own contributions on the stream of thought, the perception of things and of space, the emotions, instinct, habit and in many other directions are of fundamental importance. The work has an extraordinary vitality and individuality which make it a work of art and a classic.

In his "Talks to Teachers" and "Varieties of Religious Experience," James extended the field of psychology in two important directions. Nearly all his work was done in a somewhat opportunistic fashion. He made an engagement to give lectures, perhaps cancelled it or tried to do so, felt he could not prepare them and finally produced a masterpiece. "The Will to Believe" was a collection of addresses; the volume on "Religious Experience" was Gifford lectures, the "Pragmatism" Lowell lectures, "A Pluralistic Universe" Hibbert lectures.

Although the interest in problems of philosophy and the pluralism, pragmatism and empiricism may be traced backward to his earlier publications, they were given full and vigorous expression only in these later volumes, when James had passed the age of sixty and was already suffering from disease of the heart. It would be idle

to attempt to give here an exposition of James's attitude in philosophy. Pragmatism—the term was first used by James's friend, Charles S. Peirce, in this journal—is called on the title page of his book "a new name for an old way of thinking." It is largely the method of science applied to philosophy, but it is after all what James thought and said and wrote. His personality and its expression, the intellect swayed by the will and the emotions, have made a deep impression not only on professional philosophy, but in the world of men.

James inherited his brilliant literary skill from his father and shared it with his brother. His education was long and irregular. He did not graduate from Harvard, but studied art and was with Agassiz in Brazil. From 1872 to 1880 he was instructor and assistant professor of comparative anatomy and physiology at Harvard, then professor of philosophy, then of psychology and then again of philosophy.

It is not probable that James left unpublished manuscripts, but his letters would form a volume of surpassing interest, though it may be that they are too personal for publication. The writer ventures to reproduce the concluding parts of the last two which he received, the one from Cambridge and the other from Bad Nauheim, where he had gone for treatment of the disease that so soon proved fatal. James at first declined on account of his health to accept the active presidency of the International Congress of Psychology to be held in this country. There was no one else to take the place, so when difficulties arose he played his part with characteristic loyalty and self-sacrifice.

NATIONAL AND INTERNATIONAL SCIENTIFIC CONGRESSES

Among the various gatherings of scientific men held during the present summer two American meetings and several international congresses were of special importance. The national conservation congress held at St. Paul at the beginning of September was a truly notable event, bringing together men eminent in various pursuits to consider problems which are essentially scientific in character. President Taft's admirable address—printed in the present issue of the Monthly in its authorized form—shows how carefully he has considered questions which touch public policy on one side and science on the other. Mr. Taft stated that he inherited the policy of conservation from his predecessor, and Mr. Roosevelt and several leading members of his administration, Mr. Pinchot, Mr. Garfield and Mr. Wilson, took an active part in the proceedings. Governors of states and many men prominent in education, in philan-

My own refusal was imperatively conditioned by the state of my circulatory organs I had to introduce Bouroux to his audience 2 days ago, and could hardly speak for dyspnoea. Yours ever, W. J

the line of least discussion will be to keep the Committee as fixed With me as president Log, you Can be Vice-president Stork, and aid Watson with your counsel; and I hope that will also co operate again. I wish't "I had never said I wouldn't play at president! If I Can't preside when the time comes, I reserve the right to invite whomever I ~~[illegible]~~ damn please to take the chair.

Pray agree; and help to quench the inconceivable paltriness of spirit that seems to have shown its head for the 1st time in our American psychological world! Yours ever truly,

Wm. James

thropy and in affairs made addresses. Men eminent in scientific research were not so well represented as they should have been, but the names of Professor Bailey, of Cornell, Professor Wesbrook, of Minnesota, and Dr. W J McGee were on the program.

The American Chemical Society emphasized its national character by meeting in San Francisco. The American Association for the Advancement of Science had also planned a visit to the Pacific coast and to Hawaii, but transportation across the sea could not be arranged. The chemists had a special train from Chicago, which carried over a hundred to California, where arrangements were made for elaborate entertainments and excursions and a scientific program under the presidency of Professor Bancroft, of Cornell.

The International Geological Congress met this year at Stockholm, the International Zoological Congress at Buda Pesth, the first International Congress of Entomology and the International Congress of Anatomists at Brussels, and the International Physiological Congress at Vienna. These meetings were attended by scientific men from all parts of the world, including large numbers from this country. The Zoological Congress met last time in Boston and the Geological Congress will hold its next meeting in Canada. America and American scientific men are taking an increasing share in these international congresses, which within the past few years have assumed an important part in the advancement of science.

SCIENTIFIC ITEMS

We regret to record the deaths of Dr. Charles Anthony Goessmann, since 1869 professor of chemistry at the Massachusetts Agricultural College, known for his important contributions to agricultural chemistry; of William Earl Dodge Scott, curator of ornithology at Princeton University, and of Dr. Paul Mantegazza, the eminent Italian anthropologist.

The national memorial to Grover Cleveland is to take the form of a tower to be erected at Princeton as part of the buildings of the graduate school, with which Mr. Cleveland was closely identified during the last years of his life. The tower will be about 150 feet high and 40 feet square. It will cost $100,000, of which sum $75,000 have already been given.

Professor Joseph A. Holmes, of the U. S. Geological Survey, formerly professor of geology and natural history at the University of North Carolina and state geologist, has been appointed by President Taft director of the newly-established Bureau of Mines. —Among the representatives appointed to attend the opening of the Mexican National University on September 22 are Professor F. W. Putnam and Roland B. Dixon, from Harvard University, and Professor Franz Boas, from Columbia University.

THE
POPULAR SCIENCE
MONTHLY.

MAY, 1910

HEREDITY[1]

By Professor W. E. CASTLE
HARVARD UNIVERSITY

THE conservation movement now in progress has for its end to preserve for future generations of men the natural resources of the earth. But it goes without saying that the movement is useless unless there are to be future generations of men capable of utilizing those resources. Thoughtful persons are beginning to wonder whether this is assured. Man is the product of two sets of agencies which we summarize in the terms heredity and environment. The question has often been asked which of these is the more important, but with this we need not concern ourselves. Both are indispensable. Seed and soil combined assure a harvest, but if either is lacking no harvest can be expected.

The public is awakening to the importance of providing mankind with a proper environment through the agencies of sanitation, education and good government, and this is well. This assures a suitable soil in which a crop of healthy human beings may develop. But what of the seed? This question has not yet been seriously considered. Only in England has it been more than suggested. There Francis Galton and his associates in the eugenics movement have started an inquiry as to why it is that the average physical condition of the English nation is declining although more and more attention is constantly being given to improving the environment. Likewise in Germany statistics show a steadily declining proportion of the young men fit for military service. There is a suspicion in the minds of many, that these nations are producing the new generation of citizens chiefly from inferior family and racial stocks. If this is so the remedy is

[1] From a lecture delivered before Section F, American Association for the Advancement of Science, December 31, 1909.

obvious, though how easy of application remains to be ascertained. Would a farmer expect to have full harvests if each year he saved seed from the poorest yielding plants, or could he hope to secure the best results from his herds by selling or butchering the best stock and keeping only the scrubs? Obviously not, and no more can the civilized nations maintain their present standards of manhood if they follow a like practise.

But before any serious attempt can be made to improve the human race considered as an assemblage of animals possessed of certain desirable physical and intellectual attributes, it is obvious that we must know something about heredity in general, and how in particular each of the desired physical and intellectual attributes is produced. Considerations such as these lend general interest to the study of heredity, a subject which has always been of great practical concern to farmers, and of much theoretical interest to scientists. It is my purpose to review briefly some of the problems which the study of heredity presents, and some of the results obtained from their consideration.

"Like father like son" is a homely proverb which shows how general the recognition is that children resemble their parents. Resemblances to grandparents or ancestors even more remote are also of frequent occurrence, and it is convenient to use the term heredity as including all such resemblances, whether to near or to remote ancestors. The phenomenon of heredity is of course not restricted to human society. Heredity has for the stockman and plant-breeder a well-recognized commercial value, because by a knowledge of its laws he is enabled to produce in greater number or with greater certainty animals or plants of a particular type. Indeed, much of our present knowledge of heredity has been derived from a study of the domesticated animals or of the cultivated plants, and from the same sources we may expect to continue to draw, for here alone have we an unobstructed field for observation and experiment, the indispensable tools of scientific research. Just as the sciences of anatomy, embryology, physiology and pathology progressed but slowly so long as the phenomena of the human body alone were considered, but advanced by leaps and bounds when comparative studies on other animals were undertaken, so concerning heredity in man we have learned and can expect to learn but little from the study of man alone, but much from a study of other animals and of plants and from a comparison of the phenomena in the two cases.

Every new individual arises out of material derived exclusively from its parents. This is the basis of heredity. But it does not follow that the new individual will resemble its parents merely. It may resemble remote ancestors more strongly than either parent. For it represents a combination of materials or of qualities derived from the two parents and it is possible that neither parent may manifest all the

peculiarities which it transmits to the offspring. For the parent is made up of two distinct parts, its own body and the reproductive substance contained within that body, and the two may not be identical in character.

The reproductive substance has been called by Weismann the germ-plasm. He it was who first clearly recognized the fact that the germ-plasm is distinct from the body which contains it, and that the influences which modify the character of the one do not of necessity modify the character of the other. Thus he was able to show experimentally that mutilations of the body, as loss of the tail in mice, are not inherited, and to establish with a considerable degree of certainty the principle that characters acquired by the body as a result of use, disuse or other agencies are not inherited, because they have not affected the constitution of the germ-plasm carried within the body.

Weismann's two principles are of fundamental importance to a right understanding of heredity. They are: (1) That the germ-plasm is independent of the body containing it, or, as Weismann put it, that the germ-plasm is continuous from generation to generation, whereas the body dies, and (2) that acquired characters are not inherited.

The hottest biological discussions of the last twenty years have been waged over these two principles and the contest is by no means ended, but year by year the correctness of Weismann's contentions is more generally admitted.

Common experiences support both principles. Thus the independence or continuity of the germ-plasm has been shown from time prehistoric in the practise of castration upon the domesticated animals or upon man. The germ-plasm is localized in particular organs of the body, the reproductive glands. If these are removed reproduction becomes impossible, though all other functions of the individual persist. Further, it is possible to show experimentally that the germ-plasm

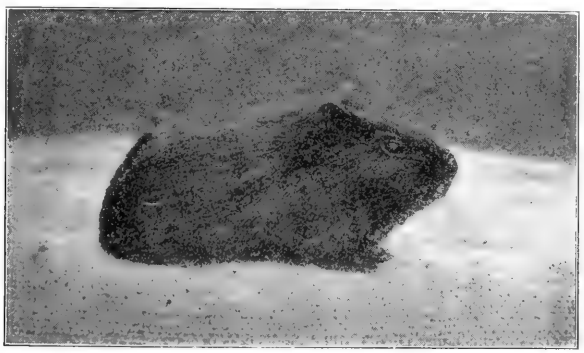


FIG. 1. A YOUNG BLACK GUINEA-PIG, about three weeks old. The ovaries taken from an animal like this were transplanted into the albino shown in Fig. 2.

FIG. 2. AN ALBINO FEMALE GUINEA-PIG. Its ovaries were removed and in their place were introduced ovaries from a young black guinea-pig. Compare Fig. 1.

transplanted from one individual into another retains the character which it originally had, quite unaffected by the changed body with which it is associated. This Dr. John C. Phillips and the writer have recently shown in the following way. The ovaries were removed from a young black guinea-pig, Fig. 1, and these were transplanted into the body of a white guinea-pig, previously castrated, Fig. 2. The white guinea-pig was now mated with another white guinea-pig, Fig. 3. Normal white guinea-pigs produce only white offspring when mated with each other, but these two have now produced in three successive litters six young, all black. Three of these are shown in Fig. 4. Evidently the germ-plasm of the black guinea-pig retained its original character even after transplantation into the body of a white one.

In order better to understand the processes of heredity we should be familiar with what takes place when a new individual is formed. The new individual, whether an animal or a plant, has its beginning in the union of two bits of germ-plasm, an egg cell furnished by the mother and a sperm cell furnished by the father. Whether the union of the germ-plasm takes place within the maternal body or not is quite immaterial; among a great many animals it does not.

The new individual, it will be observed, is dual in origin, and to its dying day it retains a dual nature. For the maternal and paternal contributions of germ-plasm retain a certain distinctness as we shall see, and may in part separate from each other at reproduction.

Each germ-cell (egg or sperm), so far as its contribution to heredity is concerned, stands for a complete organism of its species, bears the potentialities of a complete organism, and under appropriate condi-

tions can develop into such an organism. For this idea we have strong experimental evidence. It has long been known that the eggs of certain species of animals can develop without fertilization, *i. e.,* without having united with a sperm or male sex-cell. In such cases there can be no question that the potentialities of an entire organism are contained in the egg, for without any outside help the egg develops into a complete individual of the species. In recent years it has been shown that the eggs of many species in which fertilization normally occurs may by artificial means be made to develop without having united with a sperm. This is true of the eggs of sea-urchins, star-fishes, and of certain worms and mollusks. Such eggs artificially stimulated to development produce entire individuals, similar to those produced by fertilization, but possibly less vigorous.

On the other hand, a sperm cell may be made to develop, if it is allowed to penetrate into a fragment of an egg, even a fragment which lacks the important cell-nucleus. In such cases the entire nuclear material of the embryo is furnished by the sperm, yet the embryo so produced is complete, lacking no essential part, and similar except in size and vigor to normal embryos produced by fertilization.

Accordingly the evidence is fairly complete that each germ-cell (egg or sperm), considered as the vehicle of heredity, represents a complete organism, and that an individual produced by the union of two such germ-cells represents twice over each heritable trait of the species. In other words, the germ-cell is single, the individual is double.

This fundamental principle of the singleness of the germ in con-

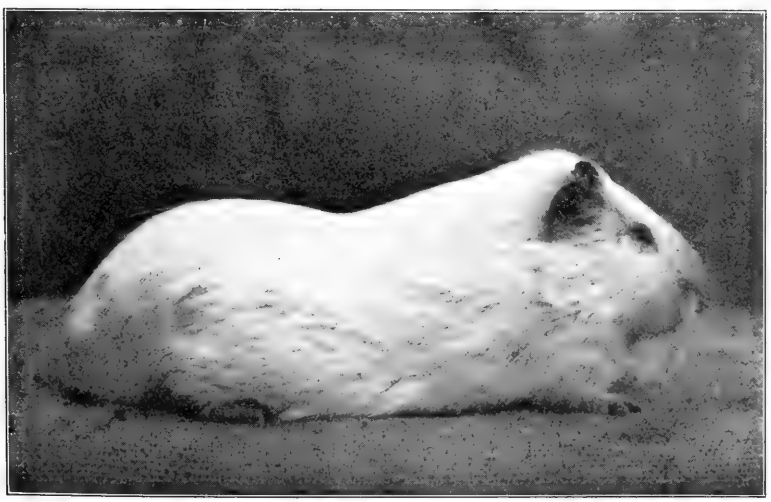


FIG. 3. AN ALBINO MALE GUINEA-PIG, with which was mated the albino shown in Fig. 2.

FIG. 4. A GROUP OF THREE YOUNG, produced by the pair of albinos shown in Figs. 2 and 3.

trast to the doubleness (duality) of the individual receives the fullest confirmation from experimental breeding.

If we mate a pure-bred black guinea-pig with a white one, the young are all black pigmented. This result seems to violate the principle previously stated that both parents contribute equally in heredity; in reality, however, that principle is not violated. The white parent has contributed its own character to the offspring, but that contribu-

tion is unseen in them simply because black hides it. The white will reappear among the grandchildren. In Fig. 5 we see a mother guinea-pig having a jet black coat. Beside her are four young of the same color as herself. The father too was black. In a word this black race breeds true. A female of this race was mated with the albino male shown in Fig. 6. Albinos have white hair and pink (unpigmented) eyes, the red eye color being due to the blood which shows through; they breed true among themselves, but the result is very different when they are mated with black individuals. Two children of the albino male and the black female are shown in Fig. 7. They are intensely black pigmented, as are all the young produced by this cross. Two of them when grown to maturity and mated with each other, produced a litter of four young, shown in Fig. 8. Three are black pigmented like the parents, but one is an albino similar in all respects to the albino grandsire. Here we notice the reappearance of the albino character after skipping a generation. The albino grandsire really made a hereditary contribution as regards the character hair color, but it did not show in the children, because black also was present in the children, and black obscured or dominated the white.

Applying our principle of single germ, dual individual to this case, we see that the facts observed are fully in harmony with it. The original cross brought together the characters B (black) and W (white) into an individual (or zygote as we call it, a joining together) B W, which showed only black. Two such individuals, a male and a female were now mated together. In the formation of germ-cells by these individuals there is a return to the single condition, B separates from W and passes into a different germ-cell. Accordingly, the mother forms eggs, B and W, respectively, and the father forms sperms of a like character. Now a new individual arises from a union of an egg with a sperm. Apparently either sort of sperm may unite with either sort of egg which it chances to meet. So there are formed in the next generation three sorts of zygotes (individuals), *viz.,* B B, B W, and W W, instead of B W alone as in the previous generation. The chances for the occurrence of these three sorts of unions are 1 BB, 2 BW, and 1 WW. Any individual containing the character B will be black; accordingly the BWs as well as the BBs will be black and there should be three blacks to one white. These are in fact the observed proportions. The white individual should transmit no other character, because it contains only W. Such is indeed the observed fact. Any two white individuals mated together will produce only white offspring. But, if our reasoning is correct, two thirds of the black individuals of this generation (*viz.,* the BWs) should transmit white as well as black, while the remaining one third, BB, should transmit only black. Experiment justifies both these conclusions. If we mate the black animals

FIG. 5. A BLACK FEMALE GUINEA-PIG AND HER YOUNG.

FIG. 6. AN ALBINO GUINEA-PIG, father of black young, like those seen in Fig. 5.

of this generation, one by one, with albinos, we find that on the average two out of three of them will produce white offspring as well as black ones, while the third one produces only black offspring.

The scientific law which governs the inheritance of albinism, and of other characters transmitted in a similar fashion, is known as Mendel's law. It applies, apparently, to all cases of color-inheritance, as well as to the inheritance of characters of many other sorts. Through its operation new combinations of the peculiar characters of individuals or of races can be obtained in the course of one or two generations. Thus when a guinea-pig showing the two coat-characters seen in Fig. 9, dark and smooth coat, is mated with one showing the combination, white and rough, Fig. 10, young are produced showing a wholly new combination, dark and rough, Fig. 11. And if these young are at maturity bred together, a fourth combination, white and smooth, appears among their young, the grandchildren. See Fig. 12. Other grandchildren manifest the combinations seen, respectively, in the parents and in the grandparents. By selection any one of these combinations may be obtained in a pure race.

Oftentimes a new combination of characters obtained through

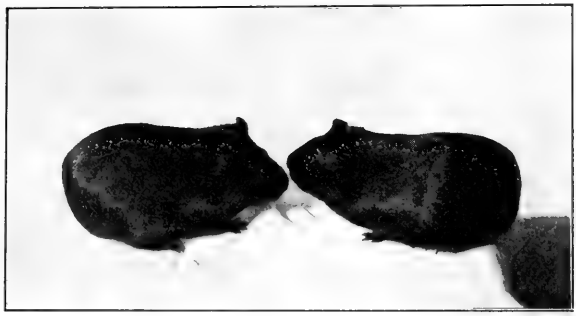


FIG. 7. TWO OF THE GROWN-UP YOUNG OF A BLACK AND OF AN ALBINO GUINEA-PIG.

FIG. 8. A GROUP OF FOUR YOUNG, produced by the animals shown in Fig. 7.

crosses coincides with a lost racial combination. Then the phenomenon is called reversion or atavism. Thus when yellow rabbits are crossed with black ones, gray offspring are obtained similar to wild rabbits in coloration. There is no longer anything mysterious about the process; it is simple recombination of different unit-characters formerly associated together in the same race, but since isolated in some of the derived races.

Very different in nature, apparently, from the Mendelian inheritance of unit-characters is the result obtained when races of animals are crossed differing in size or in the proportions of their parts. In such cases the children are intermediate in character, and the grandparental conditions do not reappear among the grandchildren. The result may be described as a blend apparently permanent. Fig. 13 shows the skulls of three rabbits, all adult, father, mother and son. The skull of the son is shown between that of his parents, the mother's skull being at the right. Size and proportions of parts are clearly intermediate in the son. No grandchildren were obtained like either grandparent in size. The color of the coat in this same family of rabbits clearly followed Mendel's law, although the size characters blended. The practical result is that one may at will produce a race

FIG. 9. A *dark smooth* GUINEA-PIG.

of rabbits of any desired size within the known limits of variation in size among rabbits, and with any of the conceivable combinations of color factors. Size variation is apparently continuous and its inheritance blending, color variation is discontinuous and its inheritance Mendelian.

Notwithstanding the seemingly radical difference between these two types of inheritance, it is possible that they may, after all, prove to have

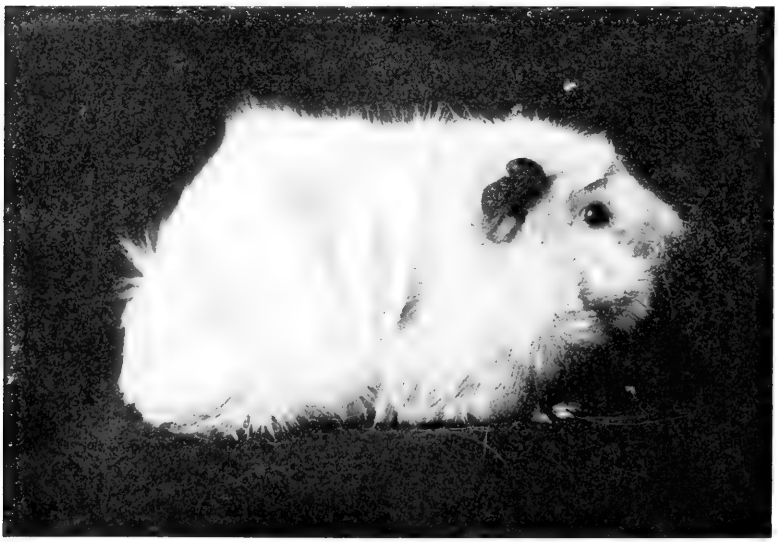


FIG. 10. A *white rough* GUINEA-PIG.

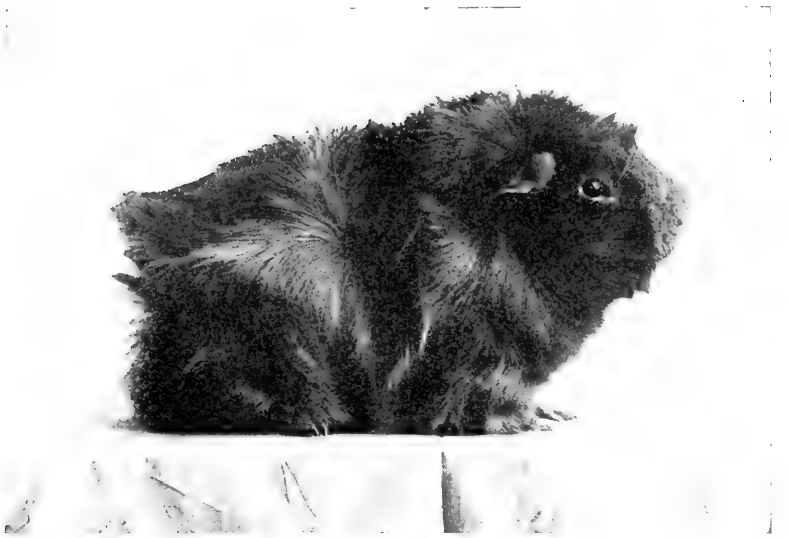


FIG. 11. A *dark rough* GUINEA-PIG, the new combination of characters obtained when animals are mated like those shown in Figs. 9 and 10, respectively.

a common basis. Blending inheritance may possibly be only a complex sort of Mendelian inheritance, in which many independent factors are simultaneously concerned. The question is one of much theoretical interest. Its solution awaits further investigation.

FIG. 12. A *white smooth* GUINEA-PIG, a second new combination of characters, but obtained first among the grandchildren of such animals as are shown in Figs. 9 and 10. Other grandchildren are like the respective grandparents (Figs. 9 and 10) or the parents (Fig. 11).

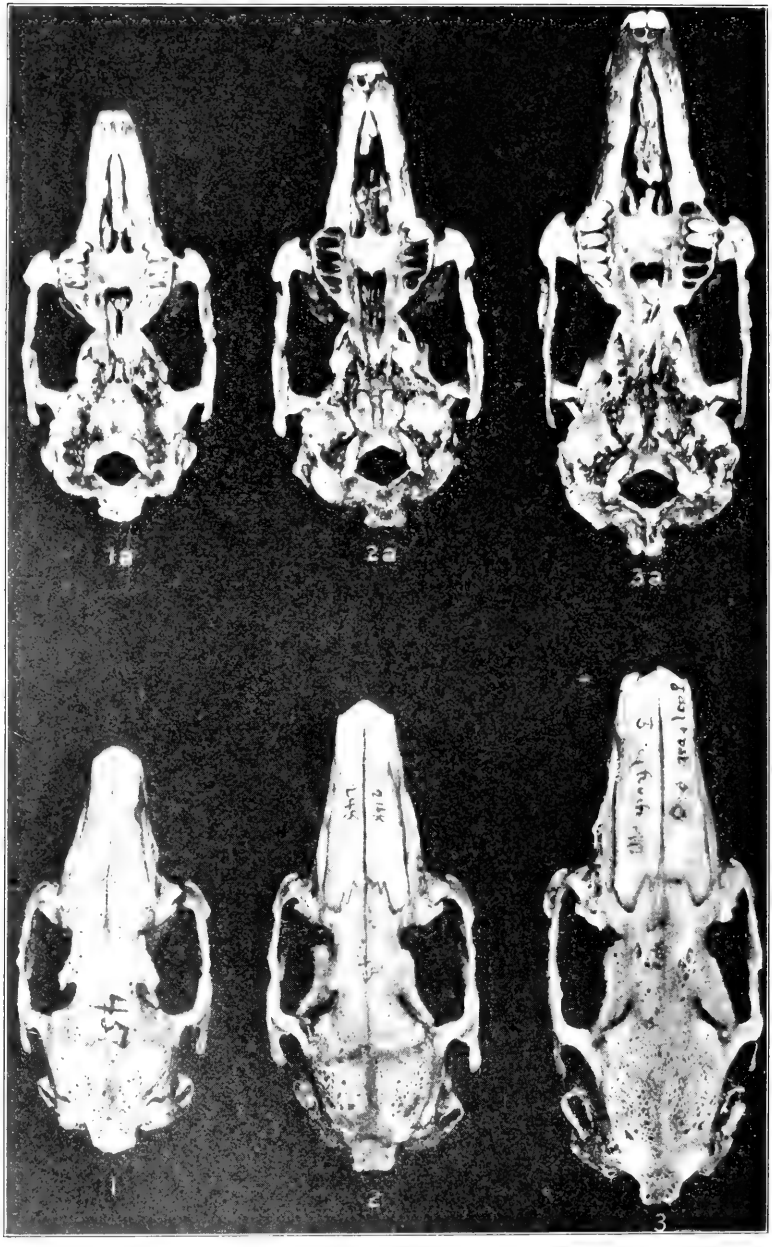


FIG. 13. SKULLS OF THREE RABBITS, mother (3 and 3*a*), father (1 and 1*a*) and son (2 and 2*a*). From Publication No. 114, Carnegie Institution of Washington, by permission.

What has already been accomplished in the study of heredity gives us a hopeful outlook for the future. We are gaining a fuller knowledge of its processes, and a knowledge of processes is a first step toward their control.

SNEEZING, SEA-SICKNESS, PAIN

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PHYSIOLOGISTS can not lay claim to a theory of pain. Even definition is difficult. The distress of bodily wants overlaps pain on the one side; fear, anxiety and similar mental states overlap it on the other. Excessive stimulation of certain organs of special sense, particularly those for touch, temperature and hearing, leads up to it. If an attempt be made to isolate, in thought, the effect in consciousness to which the term "pain" properly applies, it may be said to be the awareness of something amiss in some part of the body, irrespective of the testimony of either of the special senses. It is a modification of consciousness, not a part of its content. We have learned to associate the receipt of the modifying influence through particular nervous channels, with its provenance, just as we have learned to associate sensations of touch conveyed by particular nerve-fibers with the contact with external objects of particular regions of the skin; but such topognosis is no more innate in the one case than in the other. It is the product of self-investigation, and is based either upon the testimony of the eye or upon experiments in moving the hand to the spot. Hence in the case of organs which are out of sight and out of reach topographical guidance is unobtainable. Since we can have no knowledge of its seat, the pain is referred to some accessible part of the segment of the body in which it occurs. A gulp of very hot water, on reaching the closed sphincter muscle of the stomach—the valve which must open before it can pass from gullet into stomach—gives rise to pain which seems to have its seat in the skin over the lower end of the breast-bone. In the same way disease of the various viscera gives rise to pain and tenderness of areas of the skin of the segments of the body in which the nerves of the viscera join the spinal cord.

From a physiological standpoint "pain" and "sensation" are antithetical terms. Sensations inform. Pain is a state of consciousness which masks sensation. Sensations are transient. Their apparent prolongation is due to repetition. They are vibratory. Pain is a condition, slowly set up, slow to disappear. Even the briefest pain is long as compared with the constituent unit—a nerve wave—of sensation. It is of the very essence of sensation that it has quality or modality; the informing value of any given sensation depends upon its excluding all other forms of stimulation. The sensation of a bright red spot of light is not susceptible of confusion in place or quality with other visual sensations. Still less is it liable to be mistaken for a sensation of hearing or of taste. Pain has no modality. If it may be

justly described as stabbing, aching, burning, it owes its individual character to the form of its onset and to its duration, and these in turn depend upon either the vascular condition of the part affected—the pumping of blood through the vessels of a tissue free to expand, or packed in a bony case—or they are due to the effect upon the inflamed or injured part of muscular contractions. If the injured part be inaccessible, pain has no "local sign." If it be on or near the surface of the body the pain felt in it has or seems to have a topographical meaning; but it is very doubtful whether the mind can localize the source of pain in the absence of evidence simultaneously afforded by the nervous apparatus of the sense of touch. Many instances are on record of disease or injury to the central nervous system resulting in complete loss of sensitiveness to pain, whilst sensitiveness to touch and pressure remained undiminished. But there are no recorded cases, so far as we are aware, of complete paralysis of the mechanisms of touch and of the recognition of heat, of cold and of pressure, with the retention of normal sensitiveness to pain. Such a condition, if it were established, would make it possible for an investigator to ascertain whether skin-pain, by itself and unsupported by collateral evidence, has a topographical meaning, or "local sign"; and whether the expression pain-spot may be legitimately used, as meaning a sounding spot in the midst of a dumb area, and not merely a focus of sensitiveness at which the weakest stimulus which can evoke pain is effective.

Dr. Henry Head caused the large cutaneous nerve of the thumb-side of the forearm and hand to be cut in his own arm, in order that he might study carefully the revival of sensations which follows on nerve repair. He found that, long before he regained the ability to distinguish degrees of warmth, to feel as separate the two points of a pair of compasses, or to recognize a touch with cotton-wool, he regained his power of recognizing stimulation by agents that do harm—hot things, cold things, pricking with a pin—but his power of localizing the spot injured was extremely vague. Trotter and Davies have made similar experiments in their own persons on a still more extensive scale and have confirmed and amplified Head's results.

Investigations with the aid of new histological methods has shown that the epithelial tissues are supplied with nerve-filaments in inconceivable abundance. It is probable that the conclusion is justified that every cell of the skin, of the mucous membranes, of the lining epithelium of the air-chambers in the lungs, of the pleural and peritoneal cavities, of the various glands, is connected with a nervous thread. It is certainly true also of every muscle-fiber in the walls of the alimentary tract, of ducts and of blood-vessels. By these filaments the cells of the body-surfaces both external and internal, the central nervous system and all motile organs, are bound together.

Superimposed on this basal system are the various specialized sys-

tems of nerves which originate in organs in which their ends are so modified and so enveloped as to render them sensitive in the highest degree to one particular order of stimulus, whether of smell, sight, taste, hearing, touch, heat, cold, pressure or traction, and inaccessible to stimuli of every other class. These nerves, with the chains of neurones which link them to the muscles, *via* the spinal cord and brain, stand out as a pattern on the basal system, like the pattern formed of thicker fibers and coarser knots on a sheet of lace.

In a book recently published, "The Body at Work," I have endeavored to present a picture of the nervous system and its activities, which, although not original in any of its details, is new in their grouping and in its comprehensiveness. It is based upon the teaching that the two great functions of the nervous system, notwithstanding that they grade one into the other, must, for purposes of analysis and description, be considered apart. By the basal system of protopathic nerves all the cells of the body, with the exception of those of the connective tissues, bones, tendons and so forth, are bound together into a continuous inseparable whole. No change can occur in the nutritive condition of any part of the skin or of an internal epithelium without the induction of a nutritive change in the central nervous system and thence, onward, in the plain muscle-fibers of arteries and other structures of the segment of the body in which the inducing change occurs. As contrasted with the influence which spreads through this basal system the "impulses" which travel up the nerves of special sense are peculiar in kind or, at any rate, in intensity. In order that they may overcome the resistance of a chain of neurones they have a certain potential, and progress in pulsations or waves.

Pain is explained as due to the setting up in a particular segment of the axial nervous system of a focus "pain-conditioned" sympathetically with the injured tissues. Consciousness of pain depends upon the direction of attention to impulses which ascend through the pain-conditioned segment from end-organs of nerves of special sense. If the seat of injury be the skin it is through the specialized nerves of the injured spot that modified impulses reach the cortex of the brain. If the seat of injury be an internal organ no effect is produced in consciousness until the pain agitation of the spinal cord has become sufficiently intense, and sufficiently wide-spread, to modify impulses which ascend to the cortex from skin areas of the segment in which the viscus is situate. The pain in angina pectoris is felt on the left side of the breast bone at its lower end. This shows that the nerves of the aorta have their centers in the same region of the spinal cord as the cutaneous nerves of this area on the surface of the chest.

To give an illustration of the difference of mechanism of pain and of sensation. In a railway station lavatory I recently observed a man who absent-mindedly placed his fingers on a free-standing iron stove

to ascertain whether it was hot. It was a frosty morning in November. Obviously, the stranger had a strong prejudice that the station-master would not have thought it necessary to order a fire to be lighted so early in the winter. As nearly as I could estimate, three seconds elapsed between the touching of the stove and the ejaculation which announced with unnecessary emphasis that the man had obtained the information he desired. Had he, expecting to find the iron hot, directed his attention to the modification of his skin sensation he would have withdrawn his fingers in one seventh of a second.

One of the characteristics of incipient pain is exaltation of reflex actions. I can not by any effort of will prevent my muscles from withdrawing my hand from hot iron (although the resolute withdrawal of attention from pain-modified sensations and the forcing of a conviction that it does not exist, has in certain cases a remarkable effect in suppressing pain). Equally characteristic of established pain is the inhibition of action. A whitlow abolishes all temptation to shake the finger.

Physiologists can not investigate the phenomena of pain, although they make elaborate studies of its threshold value and of the distribution of "pain spots." It would take us too far were we to consider the evidence of a degree of specialization in the protopathic nerves of the skin which is held by some to justify the use of the expression "pain-nerves," and of the allied question of neuronic conduction of incipient or threshold pain along pain-tracts in the spinal cord.

The chief interest of the hypothesis of structural continuity through the protopathic nervous system, with its corollary of sympathetic nutritional change, lies in the explanation which it affords of the influence upon reflex action of the establishment of a pain-condition in the axial nervous system in circumstances in which, consciousness not being affected, there is no "pain."

Pain-condition which inhibits reflexes due to impulses which start in the damaged organ or skin area, greatly increases in many instances the conductivity of the portion of the nervous system which it affects for impulses which do not come from the damaged part. Such a reinforced reflex is the attack of sneezing to which many persons, most monkeys, and some breeds of dogs are subjected when the eye is stimulated by a bright light. When the gaze is directed towards a bright cloud, excessive stimulation of the retina sets up a pain-condition in the mid-brain. In the progress of evolution this portion of the cerebrospinal axis has undergone great changes. Its sensory nerves with their protopathic constituents have been drawn backwards into the great bundle of the fifth nerve, which joins the hind-brain, whilst the nerve from the retina has established a secondary connection with the mid-brain. The mid-brain receives in consequence the protopathic nerves of the eye. But the nose being the real tip of the body and anterior to the eye the sensory fibers of the skin which lines it al-

though bound up with the fifth nerve, extend forwards within the cerebrospinal axis to the very front of the mid-brain. A remarkable state of affairs is thus established. The mid-brain receives the protopathic nerves of the eye and the root-fibers of the sensory nerves of the nostrils. When excessive stimulation of the retina by bright light sets up a pain-condition in the mid-brain the every-moment impulses ascending from the nostril acquire undue importance. It is as if they had been increased in intensity by a pinch of snuff. Their urgency causes the reflex by which irritating substances are expelled.

Some persons merely feel a tickling in the nose when they look at a bright light, but do not sneeze. This phenomenon is extremely interesting. It proves that stimuli "adequate" to impress nerve-endings are not necessarily "adequate" to arouse consciousness. External forces incessantly press the button with sufficient energy to make contact. At each pressure a bell rings in the chamber of consciousness, but, if it is to attract attention, it must ring more loudly. The stimuli which gave rise to a tickling feeling were not originated nor intensified by the light which fell upon the retina. The mid-brain through which impulses passed to reach the cortex was rendered more conductile.

In normal conditions no pain results from stimulation of the retina, however severe; because the nerve-fibers which convey visual impulses from this highly specialized sense-organ, are connected, not with the mid-brain, but with the optic thalamus and the occipital cortex. It would stultify so highly specialized a sense, were its news admixed with, or modified by any influence or information not directly connected with its proper function.

Sea-sickness is another illustration of the effect upon reflex action of central agitation due to impulses which do not appear in consciousness however voluminous the sensations may be of which they are the indirect cause. The nerve which is concerned with the adjustment of the position of the body is a constituent of the auditory nerve. It comes from the semicircular canals. Never under any circumstances do the impulses which originate in these organs of orientation enter consciousness; but when a ship begins to roll, or worse, to heave, they churn up the gray matter of the hind-brain until its conductivity is so affected as to demonstrate their urgency beyond misunderstanding. Root-fibers of the vagal nerve traverse the hind-brain much in the same way as root-fibers of the fifth nerve traverse the mid-brain. Habitual, every-moment impulses ascending from the stomach by the vagal nerve, for the routine regulation of its purely domestic functions, acquire, when the hind-brain is pain-conditioned by impulses from the semicircular canals, a terrifying import, causing the explosion of numberless motor neurones. The stomach sneezes, with the zealous support of muscles of the throat, chest and abdomen. In the

early stages of the malady the same cause leads, no doubt, to reflex derangement of the secretion of the stomach involving nausea. Disturbances of vision add to the victim's discomposure, and in some small degree precipitate the stomachic catastrophe; but the effective cause is, I take it, the agitation, by impulses from the semicircular canals, of the gray matter of the hind-brain.

Hiccough, again, is an exaggerated reflex due to increased conductivity of gray matter. A child takes a cold drink, or he rapidly fills his stomach with insufficiently masticated food. The ends of the vagal nerve in the stomach are irritated. They convey an influence which sets up the pain-condition in a portion of the gray matter through which nerve-fibers from the lungs extend their roots towards the nucleus of the phrenic nerve. The diaphragm sneezes.

It would carry us beyond the proper sphere of this journal were we to consider the phenomena of inhibition of some reflexes and exaggeration of others which the modification of the normal conductivity of gray matter due to the establishment of pain-conditioned foci, brings about in hysteria, angina pectoris and many other morbid conditions.

The pain of headache is as truly "referred" as is the pain of angina pectoris, although it must be assigned to a different category. Medical men tell their patients that their headaches are in their scalps and not within their skulls. The patient finds it difficult to understand how this can be, when there is nothing the matter with his scalp; but agrees with his doctor that, were it otherwise, it would be impossible to explain the beneficial effect of a cold wet rag. Again as in sea-sickness the vagal nerve is at the bottom of the mischief. Indeed, in many persons, intolerable headache takes the place of sickness on the sea. Impulses ascending the vagus agitate the gray matter of the hind-brain. Into this pain-conditioned gray matter the nerves of the scalp pour a constant stream of impulses. Myriads of fibers connecting the scalp with the brain twang ceaselessly with messages to which, under normal circumstances, consciousness gives no heed—until a draught of cold air or the tickling of a fly's feet accentuates a certain group. Let the gray matter through which they pass be pain-conditioned, the vibrations traveling to the cortex from innumerable spots on the surface of the head produce a widely diffused dull ache which has no sensational quality, because no particular group of nerve-endings is being especially stimulated by external force. Vascular changes in the scalp due to the same cause, the exaggeration of impulses during their transit of the gray matter of the hind-brain, making believe that the scalp is injured and needs more blood, react upon the nerve-endings increasing the illusion of injury. The pain is no illusion. It is impossible to decide whether vascular changes are the first effect of vagal agitation and therefore the immediate cause of pain or whether they are merely subsidiary results of the exaggeration of sensory impulses from

the scalp. A cold compress by constricting the blood-vessels reduces the din of the multitudinous messages shouted into consciousness by the sense-organs of the scalp. If completely successful it subdues their chorus to its habitual murmur, too faint to secure attention. Long continued, and therefore damaging, contraction of the muscles which move the eye-ball, and particularly its elevator, sends through their protopathic nerves a stream of influence to the mid-brain, with which these nerves are connected, which causes frontal headache in just the same way as the influence which ascends the stomach nerve.

Would doctors be more logical if they said that the headache was in the hind-brain—the region which contains the agitated gray matter which gives pain-value to the impulses from the scalp—or if they said it was in the stomach? The irritation of nerve-endings in the stomach is the origin of the trouble, seeing that it sets up the pain-condition in the hind-brain.

Psychologists base their science upon conspicuous sensations—sensations of sufficient prominence to stand out in the field of consciousness. They can do no otherwise. But the terminology in which they have expressed the results of their analysis hampers physiology. In the process of conduction a physiologist can distinguish no stages intermediate between stimulation and muscular response. In reactions to which consciousness is adjunct, as judged by self-feeling, or, when outside oneself by attribution of self-feeling, the nerve-current may be termed a sensation, and sensations may or may not provoke attention. Nothing is gained by classifying the sequence of events into stimulation, passage of impulse, sensation, perception. Such terms are machinomorphic. The nervous mechanism is infinitely vibrating. "I always hear my clock stop" can have but one meaning. Every tick of the clock produces an answering vibration of the auditory nerve, however little attention be given to the message; and attention carries with it the idea of something which attends. Pain, as pictured in this essay, is the interpretation which the ego gives of hitherto unperceived sensations when they are increased in volume without definition. Pain is developed when impulses, without informing attributes, are raised in urgency to the level of attention.

The passage of a gall-stone from the gall-bladder to the intestine is the cause of intense pain, "referred," in the first instance, to the skin which overlies the liver. Yet the gall-bladder is insensitive. As surgeons have long been aware, the liver, stomach and other viscera may be cut, burned, scarified, without arousing pain. Laying stress on these two well-known facts, (1) the insensitiveness of the viscera and (2) their liability to become the source of referred pains, James Mackenzie has defined pain as "a disagreeable sensation due to stimulation of some portion of the cerebrospinal nervous system and referred to the peripheral distribution in the body wall of cerebrospinal sensory

nerves." When a viscus is the seat of origin of pain the impulses which ascend its sympathetic nerves excite the centers of sensory nerves in the spinal cord.

The theory which I have attempted to outline in this article is laid on the same basis, somewhat broadened. All pain is "referred"—to the right spot, if its source be in the skin; because the skin is elaborately supplied with place-defining nerves—to an organ or part, skin, muscle, joint, which the ego, during the progress of self-investigation, has discovered in the same segment of the body, if its source be in a viscus.

The body is permeated with a felt-work of nerves, unprovided with specialized nerve-endings, conveying no definite information, and in consequence without precise distribution in the seat of consciousness. This non-specialized system which binds the various parts of the body together is the mechanism through which the caliber of blood-vessels, erection of hairs, secretion of glands, contraction of the walls of ducts and of the intestines, and many other domestic adjustments are effected. It is also the medium through which the gray matter of the cerebro-spinal axis is affected sympathetically with damage to the tissues. The resultant altered conductivity of the gray matter leads to modification of the only kind of impulses with which consciousness is concerned—impulses which inform. We infer that the damage which is giving rise to a feeling of pain is in the part from which the modified impulses come.

When attempting to formulate the theory of pain it is necessary to discard the prejudice that there need be a proportional relation between the intensity of pain and the magnitude of the physiological changes which condition it. A heavy blow hurts more than a light one. Yet a change which could not be detected by any piece of apparatus in use in a physiological laboratory, if it affect the nerve-tissue of a tooth, may give rise to more pain than is caused by a crushed limb.

Another prejudice, from which it is difficult to shake free, attributes to the mind an innate knowledge of the topography of the body; an innate knowledge, that is to say, of the distribution of its news-agents, the sensory endings of nerves.

Thirdly, it is necessary to remember, when investigating the machine, that the machine is the man. It is not sufficient to design a scheme of telephone wires requiring for its use a listening ear at its center, the brain. The ear is a part of the machine. There is no need to picture a system of pain nerves, carrying news of damage to an attentive mind. A departure from the normal in the functioning of the sensory apparatus is pain.

THE CIRCULATIONS OF THE ATMOSPHERES OF THE EARTH AND OF THE SUN

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The Two Causes of Circulation on a Non-Rotating Earth

Gravity, Temperature and Pressure

IT must seem rather ambitious to attempt to treat so great a subject as that of the circulation of the atmospheres of the earth and the sun in a single lecture. It is true that if it should be discussed fully, in the technical way, it would require a great many lectures, but of course there are at the same time certain fundamental principles which are common to all circulations that can easily be studied, and then illustrated by the known facts of the circulation in these two atmospheres. All circulation depends upon two primary causes, the first being the attraction of gravitation, by the laws of the action of the earth upon its atmosphere or the great body of the sun upon its atmosphere; and, secondly, the difference of temperature which exists in different parts of a given atmosphere. If we had an earth standing still in space without rotation upon its axis and the sun were withdrawn for a considerable time, the atmosphere of the earth would gradually settle down into a quiescent state, which may be described as consisting of a series of concentric shells, each shell having a certain fixed temperature passing around the earth at the same distance from a center, as if a balloon were floating at the same height above the surface, where will be found the same barometric pressure and the same temperature in all latitudes and longitudes. If the balloon falls from one shell to another it would pass into layers of greater density, and if it rises, into layers of less density. The boundary of each shell may be conceived as a surface having the same force of gravity acting upon it, and this is called the gravity level. In this case the surfaces of equal pressure or the isobars, and the surfaces of equal temperatures, isotherms, both coincide with their own gravity levels. Everything is quiescent and there is no circulation. It is quite important to secure a clear idea of the fact that the isobars, isotherms and gravity levels coincide wherever the layers in the atmosphere have the same temperature. As a matter of fact the earth is not without rotation, and the sun is shining upon it, sending enormous masses of heat which fall upon the tropics, and it is our problem to study the effect of this heat, at certain layers in the earth's atmosphere, upon the circulation of the entire mass.

To illustrate the series of causes and effects we can take a long box or canal containing air at a certain temperature. Now if heat be applied at one end, it is evident that the air at that end is displaced in proportion to the amount of heat. The effect of heating the bottom of a column of air is to expand the lower layers of it and this produces less density in each of the lower layers, while at the same time the entire mass is lifted, provided the bottom rests upon a solid surface. Take water in a tube, heat the lower part of the tube, and the whole column will seem to rise in the tube, but the lower parts, being hotter, will necessarily have a smaller density. A common case of the power that can be produced by heat is seen in its effects in the steam engine. Similarly, the air when heated in certain localities, as over the tropics, begins to work practically like the steam engine. The air is expanded, the upper part is elevated and the lower part is rarefied. Now the effect of lifting a column which is heated in the lower part is to raise the isobar above the gravity level which is occupied before heating, and in the lower part the isobar is depressed below the position which it had before it was heated. It is now readily seen that isobars, instead of coinciding with the gravity levels, have a slope, the upper ones trending downwards towards the cold end of the canal, and the lower one sloping downwards to the warm end of the canal. Under the action of gravity a liquid or a fluid which rests on a slope of any kind tends to run down hill, just like water in a brook or a railroad train on a grade. The part which is above the gravity levels tends to get down to it, in order to destroy the slopes which nature abhors among its gravity levels. The force of gravity tries to make all the temperature and pressure levels coincide with the gravity levels, and in order to do that it is clear that currents of circulation are set up. In this way there is an effort to destroy the differences in temperature which have been produced by the sun's radiation and reduce them to a uniformity; that is, a uniform temperature at the same distance above the surface of the earth.

It becomes, therefore, a fundamental point in meteorology that the air over the tropics is heated in the lower levels by the action of the sun's radiation falling upon the earth, and that the air in the tropics is also lifted above its natural gravity position; hence, in the upper levels the air flows from the tropics towards the poles, and in the lower levels from the poles towards the tropics. We will not attempt to trace out this general circulation more fully until certain other conditions have been described.

If the heat is applied at the center of a canal, instead of at one end, the same principles operate, so that the lower part, being heated, has its isobars depressed in the middle, while the upper part is lifted so that the higher isobars are elevated above their original position. In this

case air flows from the center in both directions towards the cold ends of the canal in the upper levels, and from the cold ends towards the middle in the lower levels. In this figure we have therefore a general description of the primary motion of the air on the earth taken as a whole, by which the air flows from the tropics towards the north pole and the south pole of the earth, respectively, in the upper levels, and from the north pole towards the tropics and from the south pole towards the tropics in the lower levels. It should be remarked in passing that since the assumed canal is like a rectangular square box in our laboratory experiments, but as a matter of fact of a wedge shape in the earth's atmosphere, the circulation is not so easy as might be at first assumed. The meridians at the equator, which are one degree apart, converge to a point at the poles, so that the atmosphere when quiescent must be thought of as made up of a series of sectors or spherical wedges. Now the air in running from the tropics towards the poles runs from a broad end to a thin end of the wedge, and, since it can not congest, a very complex circulation is set up in order to enable it to escape unnatural compression. There are, however, many examples in the earth's atmosphere of masses of air which are arranged much more nearly in the form of a rectangular box canal, as shown when a long mass of cold air is pointing north and south, with a mass of warm air pointing from south to north and lying east of it, while another mass of cold air pointing from north to south is placed just east of the mass of warm air. While these masses may not in fact be very rectangular, yet we can study their action on the supposition that sections through them produce figures which are practically rectangular in shape. Suppose we have a warm mass lying between the cold masses, then the warm mass will be higher above and also lower below than the cold masses so far as their isobars are concerned. That is to say, at the upper surface of the sections if you want to get a mass of air at a certain density it will be necessary to go higher up in the atmosphere over the warm mass than over either of the undisturbed cold masses lying on the side, and furthermore, if one wants to get a mass of air of the same density as that lying on the under side of the cold section, it will be necessary to go down lower in the warmer mass, that is, nearer the surface of the ground, in order to find it. Applying now our principles of circulation, the action of gravity will tend to draw the upper part of the warm mass over upon the cold masses to either side, and thus tend to destroy the inequality in the elevation of the upper isobar. Similarly the cold masses will tend to flow under the warm mass from either side, and remove the discontinuity in the positions of the lower isobars. Not only do these masses of warm and cold air tend to overflow and underflow sidewise, but they seek to move, as it were, along the meridians, northward and southward at the same time; hence the long currents

of circulating air are naturally produced so that the warm and cold begin to interflow among one another, as a matter of fact in very complicated curves, the purpose of this being to restore the coincidence between the isobars, isotherms and gravity levels, which had been disturbed primarily by the heat of the sun falling upon the tropics of the earth. Having considered thus briefly the general principles which would induce circulation on a non-rotating earth, we can take up somewhat more fully the effect produced upon this same circulation by the fact of the earth's rotation; that is to say, we can discuss the circulation upon a rotating earth.

The Gyrations in the Atmosphere set up on a Rotating Earth

It will be desirable to define a few terms which occur in circulation that will enable us to speak more briefly of the subject in its advanced stages. *Rotation* will be confined to the motion of a mass of matter, as the sun or the earth, which is revolving about its center. The rotation of the earth takes place in 24 hours; the sun rotates on its axis in 27 days more or less. *Revolution* is the motion of a mass about a center from which it is separated by a radius, as the revolution of the moon about the earth, or the earth about the sun, or of an ideal particle of the atmosphere revolving about a center at a variable distance. *Gyration* is a more complicated motion. It consists of the revolution of a mass about its center at a given radius while the center itself is moving in some direction. If the moon revolves about the earth and the earth revolves about the sun, each particle of the moon will describe a series of gyrations forming a looped curve which describes this motion. If a particle of air in a tornado revolves about its axis while the axis is moving over the surface of the earth, the particle will gyrate or form a looped curve relatively to the surface of the earth. *Vortex motion* is more complex still. A vortex may be described as consisting of a series of concentric tubes. The motion of the tube is such that the inner tubes revolve about the axis faster than the outer tubes. A particle of an inner tube has a certain velocity which is greater than the velocity on an outer tube, but the velocity of the inner tube multiplied by its radius is equal to the velocity of the outer tube multiplied by its radius. If a particle moves from an outer tube to an inner tube in a vortex it can do so only by increasing its velocity of rotation. If the particle moves from the outer tube towards the inner tube and at the same time ascends along the axis, the particle will move in a helix. The *helix* may be contracting, with greater angular velocity, or expanding, with less angular velocity. In the latter case the particle moves from the inner tube to the outer tube of a vortex. A *torque* is a complicated motion which applies to a mass taken as a whole. The earth is covered by a shell of air and its actual motion may be described as a

torque. Take a bundle of paper rolled up about a center line and grasp it in the two ends. Now twist the roll so that the ends move in opposite directions. At some point in the middle there will be no motion of the particles, while the upper particles of the paper move in one direction and the lower particles move in the opposite direction. In the case of the earth's atmosphere, in each hemisphere, there are two great currents each constituting a torque. In the northern hemisphere the northern current moves eastward and is called the eastward drift. In the northern tropic the great current moves westward and is called the westward drift. There are really two torques in the earth's atmosphere, one belonging to each hemisphere, so that in the tropics, as a whole, the movement is westward, while north of the Tropic of Cancer it is eastward, and south of the Tropic of Capricorn it is also eastward. Instead of the atmosphere running from the tropics towards the poles in the meridional wedges, as a matter of fact it circulates in these great torques. In the northern hemisphere north of the latitude of 33° there is a great eastward drift and between the latitudes of 33° there is a great westward drift. Along the latitude of 33° approximately there is no general motion either east or west, and this corresponds with the part of the paper bundle which does not get twisted when the upper and lower ends are moved in opposite directions.

When a current of air moves in any direction it tends to break up into two *volutes* or spiral branches. If one takes a dandelion stem and splits it along the center, the two pieces will curl over in opposite directions and form beautiful right and left handed spirals. If a warm current of air ascends from the ground and forms a cloud, it can be seen that the middle of the cloud is ascending while the edges are descending in a gentle spiral of an umbelliform shape. If a southerly current of air moves northward it will tend to open up in two branches to the right and left. If a northerly current moves southward it will tend to open up in two branches to the right and left. The left-hand branch of the southerly current and the right-hand branch of the northerly current will tend to interlock or intercurl. The great current in the tropics which moves westward, instead of proceeding due west around the earth, tends to break up into two great volutes, one curling into the northern hemisphere, and one curling into the southern hemisphere. The word *curl* has several meanings, the first is that in which it has already been used; namely, a spiral rolling about a center. The second is connected with vortex motion and is really a name for a part of the helix action. If a mass of air moves in a spiral towards a center, it is evident that it can not proceed long in this way without some provision for its escape. If it moves in a spiral on a given plane it must begin to escape along a line perpendicular to that plane. If a circle is taken as a boundary in a given plane, and a certain mass of

air moves into this circle on spirals, then there will be a certain amount of the air moving perpendicular to the plane of the circle. This whole action of spiral movement inward and vertical motion from the plane is called a curl and it depends upon vortex laws. In a tornado or hurricane the curl is illustrated by air which ascends as a current while the air is moved inward along certain spirals. It is also illustrated in electricity and magnetism where an electric current passing around the helix surrounds a magnetic field perpendicular to the sections of the tube along which the electric current is flowing. Electric currents and magnetic fields are also related to each other by the law of the curl, and this evidently goes back to the idea of the helix or vertical spiral.

We may now resume our discussion of the circulation of the air on the rotating earth, repeating to some extent what has been said in defining these special terms. Take a globe and in the tropics place an arrow pointing westward between the equator and the latitude of 33° both north and south. To the north of 33° place an arrow pointing eastward, and in the southern hemisphere to the south of 33° place an arrow also pointing eastward. These represent in a general way the action of the atmosphere as consisting of two great whirls in each hemisphere, thus composing a torque on a hemispherical scale. Draw a ring around the earth in latitude 33°, cutting out a section of the atmosphere. If this ring moves northward it will evidently contract, and to have the same angular momentum, that is, mass energy, it must rotate faster about the axis as it approaches the pole. This constitutes in a way an illustration of vortex action whereby a particle passes from an outer to an inner tube and consequently revolves faster about the axis. Take another section south of latitude 33°, cutting out a ring of atmosphere. If this ring moves southward it must rotate slower because it is moving to a region at greater distance from the earth's axis if it is to retain the same momentum or energy of mass in motion. The importance of these great torques in the earth's atmosphere can be seen from this general fact that while the weight of the earth's atmosphere taken as a whole is very great, and is, generally speaking, in vigorous motion, yet the currents as a whole are so interbalanced that the mass energy moving eastward is exactly equal to the mass energy moving westward when the whole atmosphere is summed up. This is proved by the fact that the rotation of the earth on its axis does not change by the smallest fraction of a second from century to century, or at least astronomers have been unable to detect any change in the period of the earth's rotation so long as observations have been continued. If this balance of eastward and westward momentum were not perfect, it would immediately be shown by a change in the period of the rotation of the earth upon its axis.

The picture which is presented by these ideal rings starting from latitude 33° in each hemisphere and moving respectively towards the poles and towards the equator is not very complete, because the rings do not continue to move as a whole with an increase or decrease of velocity. If we examine the actual velocity of the air in a given latitude, as over the city of Washington or again in the tropics, as over the Barbadoes, we shall find the following facts: At the ground in Washington the wind averages about six meters per second eastward; at an elevation of 2,000 meters the eastward velocity is about eighteen meters per second; at 4,000, it is about twenty-four meters per second; at 6,000, it is about twenty-eight meters per second; and at 10,000, it is about thirty-four meters per second.

Above this level the air moves eastward at a rate of about forty meters per second; that is, ninety miles per hour. That is to say the eastward velocity or the eastward drift increases upwards with the distance from the ground. Now these velocities are maintained throughout the year with certain seasonal variations, though, of course, they are at times disturbed by certain local circulations as when storms disturb the normal movements of the air. The gyrating rings then which we first considered may be more accurately described as sheets of air parallel with the earth's surface which flow over each other at different speeds, the upper sheets flowing faster than the lower sheets. This may be practically seen in the cirrus clouds which are higher than the cumulus clouds, and move eastward as a whole with twice as great velocity. It is evident that we have here another type of vortex motion. What we first considered in the course of our definition was a vortex in which the inner rings rotate faster than the outer rings, but in this case of the torque in the northern hemisphere, for example, we have the upper rings moving faster than the lower rings. This apparent inconsistency may be reconciled by assuming that the axis of the upper rings instead of being a line, as in the other case, is really a spherical surface high above the ground outside the earth's surface, to which the actual motion has to be referred. Mathematically considered such a spherical sheet is in certain aspects equivalent to a line so far as the reference of motion is concerned; that is, the motion may be a maximum along a spherical sheet in one case, or a maximum around an axial line in the other case.

Turning now to the tropics and examining the motion of the air in a vertical section just as we did in the north temperate zone, we find that the westward motion is distributed very differently. At the surface the westward motion is greatest, and it decreases gradually on going upwards from the ground till at 10,000 meters or so it has decreased to zero, and above that region an eastward motion sets in, gradually increasing with the height. The westward branch of the torque

then, is strongest at the surface and decreases upwards. The eastward branch of the torque is a minimum at the surface and increases upwards. We have several times referred to the latitude of 33° north and south of the equator as separating the eastward branch from the westward branch of the torque, but it has now been indicated that at about 10,000 meters above the tropics the westward branch changes into an eastward branch of the torque. As a matter of fact the surface which separates the westward branch from the eastward branch spans the tropics in an arch resting on the ground at 33° of latitude and crossing the equator at 10,000 or 12,000 meters above it. Beneath this arch the western torque is included with its maximum motion at the bottom; above this arch with a broad base in each temperate zone rises the eastward torque in which the velocity increases upward and gradually overspreads the tropics in the higher elevations, the northern branch reaching southward, and the southern branch reaching northward in a comparatively thin shell till they touch somewhere above the equator. All this circulation therefore constitutes a complex vortex which can be referred to distinct mathematical laws. If the atmosphere were willing to circulate in this simple manner it would not be difficult to adapt our mathematical analysis to it, but unfortunately, instead of moving so that the branches of this torque remain intact and retain their theoretical individuality, there is a continual interchange or passage of currents from one branch to the other in a rather irregular way which it will be necessary more closely to examine.

The Circulation on the Rough Rotating Earth

The circulation which we have been describing might possibly be set up on a perfectly smooth globe having the size and shape of the earth, but the presence of continents and ocean areas, the mountain ranges stretching north and south on the American and east and west on the Euro-Asiatic continent, facilitate the breaking of these theoretical branches of the torque into great circulating masses which interplay among each other. It is evident that the Rocky Mountains of North America and the Cordilleras of South America tend to stop the westward currents in the tropics and the eastward currents in the temperate zones. On the other hand, the Himalaya range in Asia tends to hold the westward current in the tropical zone and the eastward current in the temperate zone. There are thus certain places, that is, certain longitudes, where the currents tend to curl from the tropics into the temperate zones. A conspicuous instance of this occurs in the United States, where there is a continual outpouring of warm air from the Gulf of Mexico over the Mississippi and central valleys of the United States. While the trade winds in the tropics tend to blow from the northeast, it is known that immense masses of air move

from the tropics over the United States from the south, quite contrary to the general principle; and similarly, though not so conspicuously, a case is found in South America and south Africa. On the contrary, the warm air in the lower levels over the Indian Ocean, whose winds are called monsoons, simply beats upon the great mountain ranges to the northward of India without penetrating the temperate zone in Siberia. In this way certain great circulations called centers of action form in each hemisphere. There is one over the middle Atlantic Ocean; another over the middle Pacific Ocean of the northern hemisphere; and there are other corresponding centers of action in the southern hemisphere. These are especially well marked during the summer time when the ocean is cool and the land air is warm. In the winter time the tendency is to form centers of action over the land areas instead of over the ocean areas, but the process is much more irregular, and in the United States it is exhibited chiefly by a succession of cold waves which traverse the United States from west to east. Referring to the center of action over the middle Atlantic Ocean in summer, we know that the winds near the American side are from the south or southwest. On the Atlantic Ocean in latitude 35° to 40° north the winds are blowing eastward, and in latitudes 25° to 30° they are blowing westward; on the European side they are blowing from the northwest and north. The consequence is that the United States is bathed during the summer with warm, moist winds in the eastern half, and with warm, dry winds in the western half of the continent. In Europe, on the contrary, the northerly winds prevail, and it follows that the American continent is warm during the summer while Europe is cool, and this is the cause of the annual migration of tourists from America to Europe instead of from Europe to America. The control of the climate of Europe by the American Gulf Stream is a myth. As a matter of fact the European climate is controlled by the great currents of circulation referred to these centers of action.

More generally, warm masses of air find their way from the tropics into the temperate zones by very irregular paths, and cold masses find their way from the northern latitudes into the temperate zones by very irregular paths. A similar statement applies to the circulations of the southern hemisphere. The disturbances in the general circulation which are produced by the land and ocean areas make it well-nigh impossible to reduce meteorology to any simple scientific system. The irregularities produced by the interaction of these warm and cold masses are so great that the problem of forecasting seems to bid defiance to any clear classification. The eastward drift over the United States is, of course, the basis of any possible forecasts, and the irregularities caused by the interpenetration of the warm and cold masses, one after the other under the action of gravitation, produce

what we call our storms, but technically are called cyclones and anticyclones. It would be beyond my province to attempt to analyze the technical side of the theories of cyclones and anticyclones, and yet the subject of circulation would be so incomplete without at least alluding to the prominent attempts which have been made to solve these great questions that I shall venture a few remarks along this line.

The circulation of the air is classified as general and local, "general" applying to the whole hemisphere, of which some description has been given, and "local" as applying to the individual storms and their accompaniments. The local storms are known as cyclones and anticyclones, hurricanes, tornadoes and water spouts. They are all features or phases of the circulation and can be referred back to a few simple mathematical laws. Two attempts were made to solve the question of the general circulation, but the year 1896–7, which represents a new era in meteorology, when the international cloud observations were established under the leadership of Dr. Hildebrandsson, marks an epoch in the theory of the subject. I refer to those of Ferrel and Oberbeck regarding the general circulation. They had one picture in mind, namely, that of the simple canal, heated at one end, to which allusion was made in the early paragraphs of this lecture. They conceived the air to flow from the tropics northward towards the poles in the upper levels, and from the poles towards the equator in the lower levels, the northward current being separated from the southward current by a neutral plane along which there was no motion. Ferrel discussed the equations of motion adapted to the general hemisphere, and threw considerable light upon the subject. He conceived the rings of parallel 33° to move towards the poles with increasing velocity, and he made serious efforts to account for the fact that the velocity in higher latitudes is comparatively moderate instead of excessively great, as his equations demanded. If Ferrel derived an excessive velocity near the poles, Oberbeck, as a result of his complex integration, derived an excessive velocity in the upper levels over the tropics. Neither of these authors accounted for the reversal of direction from west to east at a moderate elevation, as 10,000 meters over the tropics, nor did they attempt to take into account the great irregularities in the circulation in an east and west direction, which we have described in discussing the centers of action. The result of the work of the Weather Bureau in the international cloud observations in the year 1896–7, was to destroy this theory of a neutral plane separating the upper northward current from the lower southward current. In place of that it was explained that these interchanging currents, instead of passing over each other at different levels, really interpenetrate and pass by each other on the same level; that is to say, warm air moves from the tropics towards the poles in all levels, and cold air from the poles towards the tropics in

all levels. The first theory can be illustrated by sliding the fingers of the smooth hands over each other in opposite directions, while the second theory can be illustrated by sliding the fingers between one another on the same level; the fingers of the one hand will represent the warm currents and the fingers of the other hand the cold currents. This new view is really revolutionary because it renders inapplicable the integrations which were attempted by previous authors. Unfortunately the problem has become in this way so very complicated, that no one of sufficient ability has yet been found to carry out the necessary mathematical analysis with anything like fullness or precision. At present meteorologists are engaged, by means of balloon and kite ascensions, in determining the nature of the currents from the south and from the north which prevail in different localities. Europe has already done a great deal of work in this direction, and the United States has recently made a beginning. A few soundings have also been made over the Atlantic Ocean. Generally speaking, however, this is a great field of research which it will require much money and time to adequately complete. The circulation of the atmosphere, therefore, is a great and fascinating problem for future development, and indeed it may require more than one generation of scientists to bring it into subjection.

We have described the cold and warm currents as interpenetrating on the same levels like the fingers of the two opposite hands. Gravitation takes these warm and cold masses and seeks to make them interpenetrate yet more intimately, so that the warm masses will become more cooled, and the cold masses more warmed, and the isobars and isotherms coincide with each other and the gravity levels. It is a curious fact that masses of warm and cold air having any size are exceedingly reluctant to mix with one another; that is to say, the interchange of heat is a molecular process which naturally goes on slowly, and in accomplishing it, in the atmosphere, a great deal of energy must be expended. The great masses are first torn into shreds along their edges, and are gradually fritted away in the local cyclonic circulation. The energy that is felt in storms of any kind is merely an illustration of this thermodynamic process of interchanging temperature.

The Local Circulations

Historically speaking, the year 1896–7 marks the beginning of a period of transition in the history of local as well as general theoretical meteorology. There have been two schools of meteorology: one American, whose head is Ferrel, and one German, of which Guldberg and Mohn, Sprung, Oberbeck, Margules and Pockels are leaders. These two schools agreed in one particular, namely, in that they assumed that the cyclonic and anticyclonic circulations are symmetrical about a center.

The first break in this theory was also made by Professor Bigelow in the cloud work of the international year, when it was shown that the distribution of warm and cold masses in the anticyclone was not symmetrical but asymmetrical. In the symmetrical theory the center of motion coincides with the center of heat or center of cold; in the asymmetrical theory the center of motion is located near the edge of the warm and cold masses. The actual cyclone is warm on the one side and cold on the other side of the center, and likewise the anticyclone is cold on one side of it and warm on the other side of it. The northerly cold current, therefore, has a cyclonic center on the east side of it and an anticyclonic center on the west side of it, while the southerly warm current has an anticyclonic center on the east side of it and a cyclonic center on the west side of it. These differences are also fundamental. Ferrel treated the equation of motion by one solution, quite similar to that which he applied to the general circulation of the hemisphere, and he found the vortical torque for the cyclone clockwise on the outer part, anticlockwise on the inner part, with complex lines of flow connecting them. The theoretical difficulties are quite obvious when we consider that such a vortex as Ferrel worked out is applicable only to a fixed mass of air; for example, put a mass of water in a cylindrical vessel and sprinkle sawdust in it so that the stream lines can be followed by the eye. If now heat is applied to the center it will boil along the stream lines indicated by Ferrel's vortex, and especially so if the glass vessel is rotating on its axis. This would make our cyclones storms in which the same mass of air is boiling over and over again along these fixed lines, whereas we have shown that the cyclonic circulation is simply built up by currents of air which are streaming through it in a very irregular way, and, anticipating the conclusion which we have reached in our research, it may be asserted that the cyclone, besides being asymmetrical, conforms only loosely to any known type of theoretical vortex. The German school of meteorologists also discussed the symmetrical vortex, but by another mathematical process. There are two other solutions of the second equation of motion, one of which was assumed to apply to the outer part and the other to the inner part of a cyclone. The solution for the outer part has no vertical current, while the circulation for the inner has a vertical current, quite like that in the vortical helix, such as may be illustrated by the ordinary tornado tube. Many attempts were made to join the outer part and inner part in a single set of equations, the results conforming very loosely to the observed facts in nature regarding the velocity and angular directions. It is not too much to say that neither of these systems of solution will find more than a very small application in practical meteorology. Ferrel discussed the three equations of motion, one by one, giving certain practical inferences which he found more

or less illustrated in nature, but he never succeeded in uniting the three equations in one comprehensive system. The Germans approached more nearly a satisfactory solution, but as already stated, the assumption that cyclones and anticyclones are symmetrical, respectively, about warm and cold centers, is no longer tenable. We have already made the assertion that the asymmetrical cyclone, as it occurs in nature, does not conform satisfactorily to any homogeneous vortex. It will be possible to show how this is by giving a few details regarding waterspouts, tornadoes and hurricanes, which will lead up to this conclusion.

Local Vortices in the Earth's Atmosphere

A large waterspout was seen at Cottage City, Mass., in the Vineyard Sound, on August 19, 1896, about eight miles distant from Cottage City. Fortunately a series of good photographs was secured of the waterspout and its cloud, which together with the meteorological data, have enabled us to compute the dimensions and the velocities of motion in all parts of it by means of the vortex formulas. It happens that the same cloud developed two types of vortex, at short intervals of time between them. One is the funnel-shaped vortex and the other is the dumbbell-shaped vortex. Fig. 1 gives an illustration of a section

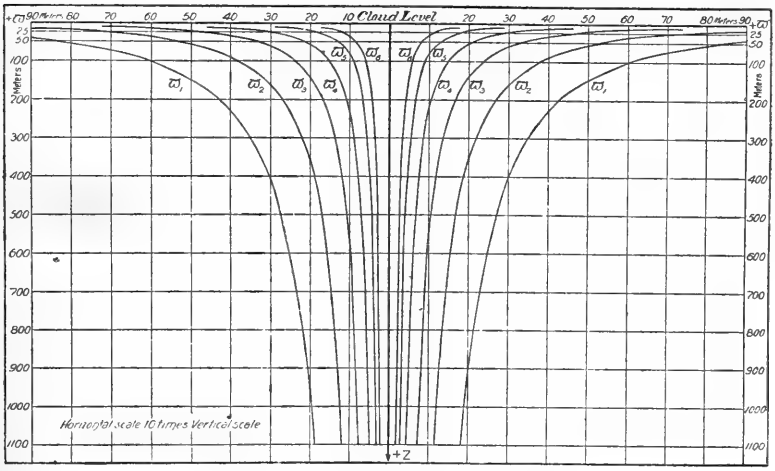

Fig. 1. Funnel-shaped Vortex.

through the funnel-shaped vortex, and shows the boundary of the several vortex tubes. The horizontal dimensions are multiplied by ten for the sake of showing the relative dimensions more plainly which exist from one tube to another. It will be noted that the distances between the successive tubes get smaller and smaller in a geometric ratio towards the axis. They concentrate at the lower part, and expand so that the lines become parallel to a horizontal plane in a region at

the level corresponding to the base of the cloud. Fixing attention upon any one of these tubes, as the first or outer one, the theory indicates that a particle of air which is lying on that tube in the lowest level continues throughout its motion to follow the same tube. This particle rotates in a spiral about a central axis gradually rising from the ocean towards the cloud, and, rotating in larger and larger spirals, at last it flows out from the axis parallel to the surface of the cloud itself. On this outer tube the particle at the sea is moved with a velocity of 22 meters per second and gradually rises upwards and changes its velocity through 20, 18, 15, 12, 7, 5, 2 meters per second quite near the surface of the cloud, and finally the velocity falls to zero. At the sea level the velocity is in a circular direction around the axis; at the cloud level it is moving in a radial direction directly away from the axis. On the outer tube having a large radius the velocities as already given are small, but on the same levels on tube No. 5 quite near the axis the velocities on the same levels become, respectively, 182, 159, 136, 110, 80, 44, 31, 14 meters per second near the cloud level, and they finally run out to zero. With such enormous velocities as 182 meters per second at the sea level, the causes of the turmoil and destructive effects which are always found in the case of waterspouts and tornadoes passing over the land are readily appreciated. Illustrations of the destructive effects of tornadoes are commonly accessible. The purpose of such a vortex is to lift a mass of air, as in a suction pump, from the surface of the ocean to the cloud, and in this case it is computed that 2,468 cubic meters of air are lifted in each second through each section of this vortex tube. These natural lifting pumps are evidently of great efficiency.

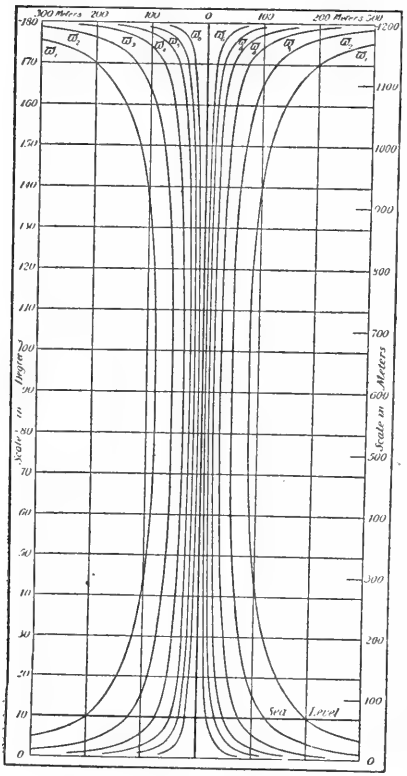

FIG. 2. DUMBBELL-SHAPED VORTEX.

The dumbbell-shaped vortex operates on substantially the same principles, though the details are different. In this vortex the air begins at the sea level to flow inwards towards the axis in a spiral which contracts up to about 500 or 600 meters above the surface of the sea, and then it begins to expand as in the funnel-shaped vortex. The dumbbell-

shaped vortex is really composed of two funnel-shaped vortices, the lower one pointing upward and the upper one pointing downward, meeting half way between the two planes of reference. This vortex is really a more efficient lifting pump than the other one just described, and it is found that 16,452 cubic meters of air are moved upwards through each tube per second, so that the dumbbell-shaped vortex is carrying 6.7 times as much air upward as the funnel-shaped vortex. A careful examination of this dumbbell-shaped vortex at Cottage City shows that the lowest sections are not fully developed. The outward curvature of the tube is plainly shown on the picture, but at sea level it is cut off or truncated by the friction of the tube against the water of the ocean. The cutting off of these vortices at some section above their theoretical lowest plane seems to play an important part in practical meteorology.

On May 27, 1896, a violent tornado of large dimensions passed over the city of St. Louis, causing great destruction in Lafayette Park and thence to the bridge over the Mississippi River. The enormous power of the forces which accompanied this vortex is shown on many pictures which were secured at that time. Large trees were twisted off

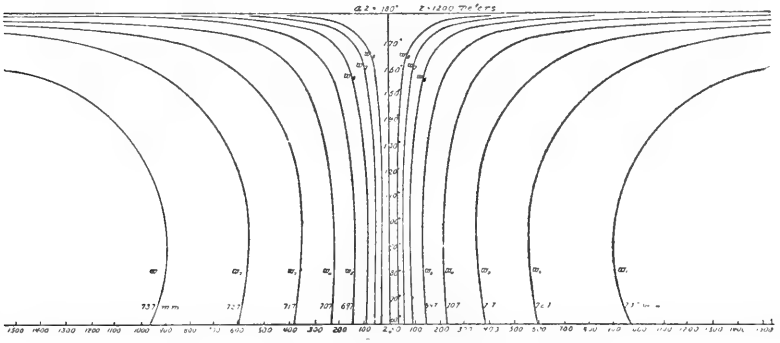

FIG. 3. TRUNCATED DUMBBELL-SHAPED VORTEX.

and stripped of their branches; buildings were overturned and destroyed in every conceivable way; heavy iron girders and stone work of the bridge were destroyed; and in short almost limitless powers seem to have been at the disposal of this great vortex. Fig. 3 shows a section of this vortex, the relative distance apart of the tubes, and the part which has been cut off or truncated at about one third of the distance from its lower plane of reference, several hundred meters below the surface of the ground. It has been shown that this St. Louis tornado was about 47 times as efficient as the large Cottage City waterspout in its lifting power, and that at the surface of the ground it developed somewhere between 150 and 250 meters per second; that is, 340 to 560 miles per hour. While it is not probable that these enormous theoret-

ical velocities can develop near the center of a great tornado on account of the retarding effects of friction where the wind moves over a rough region like a city, yet it does show where the enormous power resides that is always observed in these conditions. It might develop, therefore, a pressure of 5,000 or 6,000 pounds per square foot. This is, of course, very much more than would be necessary to make all the destruction that has been noted.

Hurricanes such as are observed in the neighborhood of the West Indies, and the typhoon, which is the name of a hurricane in the neighborhood of the Philippine Islands and China Sea, are truncated dumbbell-shaped vortices built on exactly the same principles as the St. Louis tornado, only they are very much larger in their dimensions.

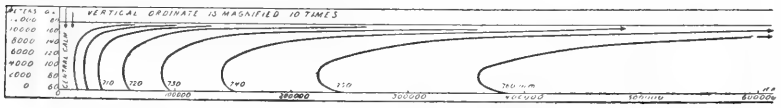

FIG. 4. HALF SECTION OF A HURRICANE VORTEX.

The tornado generally ends at a level something like 1,200 meters above the ground, and it is usually much less than half a mile in diameter. The hurricane, however, is probably 12,000 meters thick, and it extends several hundred miles in diameter. This makes the hurricane a very thin mass of air of broad extent, as compared with the word tornado, which is a relatively high mass of air and narrow in extent. We can construct the velocities in the hurricane from our meteorological data, and show that the winds blow at a certain angle, which conforms to the section that cuts off or truncates the vortex at a certain plane. These angles should be more fully explained. On the lowest plane the wind flows radially and directly towards the axis; on the uppermost plane it flows radially and directly away from the axis; at a middle section, half way between these two planes, it flows in circles tangentially around the axis. In passing from the lower plane to the upper plane the wind gradually makes a larger angle with the radius; first 10°, then 20°, then 30°, and so on up to 90° at the middle plane half way up the tube; then 100°, 110°, and so on up to 180°, which represents the wind flowing radially away from the axis. If now a vortex is truncated at a certain plane, all the winds on that plane will make a given angle with the radius. If a truncated plane is one third the distance up the axis then the wind will make an angle of 60° with the radius; that is, it will blow in at an angle of 30° from a circle. This is about the angle of the wind which observers have recorded in the case of hurricanes, and hence it is proper to infer that the truncated section should be drawn at about the distance indicated from the lower plane.

The *ocean cyclone* is a mass of air still larger than the hurricane,

circulating on practically the same vortical laws, but unfortunately it shows indications of not being able to follow the law strictly, especially in the inner portions of it. The outer part of a strong ocean cyclone, where the barometer drops to 28 inches of pressure at the center, is very much like an enormous hurricane in its formation, but near the center the angles and the velocities begin to break away from the pure vortex law. This is probably due to the great extent of the wind areas, and consequently the congestion, and to the fact that the ocean cyclone is not deep enough, although it may be 3 or 4 miles high, to carry out fully the requirements of so large a vortex of a pure type. It is known that hurricanes are vortices which are 6 or 7 miles deep. The large ocean cyclone is probably not more than 4 miles deep, and the great land cyclone is rarely more than 2 or 3 miles deep.

The *land cyclones* in the United States conform to the pure vortex law less perfectly than does the ocean cyclone. The pressure in the land cyclone usually stops at about 29 inches near the center. Its depth is usually about 2 or 3 miles. It may cover a diameter of 2,000 miles. These dimensions are evidently unfavorable for the development of a pure vortex. Furthermore, the distribution of the temperature in the land cyclone is entirely different from that in the pure hurricane, and this too prevents the land cyclone from developing according to the perfect law. Furthermore, the cyclones of the temperate zone develop in the lower levels of the great eastward drift. In these lower levels the eastward velocity of the drift is not very high; something like ten meters per second. At the height of two or three miles the eastward drift is something like twenty to forty meters per second. It becomes evident, then, that a vortex which develops in the lower levels, from any set of causes, must lift its head into a rapidly flowing stream of air, and this necessarily will tend to break down the intruding head by stripping off portions of it and detaching the upper portions of the vortex from the lower portions. Now a vortex can not develop except as a complete individual. If it is intruded upon by cutting off the lower section, as in the hurricane over the ocean, or by the upper sections thrusting themselves into the stream of the rapidly flowing eastward drift, it is evident that this is a sufficient cause for the partial destruction of the vortex system. In the theoretical vortex, above the middle section, the wind has an outward component increasing with the height, as already explained. Below this section it has in every cyclone an inward component. Now as a result of the cloud observations which were undertaken by the U. S. Weather Bureau during the international cloud year 1896–7, in which between 6,000 and 7,000 observations were made by means of theodolites upon the direction of motion in the different cloud levels, it was found that there was an inward component over the cyclones in all levels from the ground up

to four or five miles high. The strongest inward component was in the strata cumulus levels about two miles above the ground. Above this level and below it there was a radial inward velocity of a certain value corresponding to each level. There was no clear indication that the inward component in the lower levels reversed to an outward component in the upper levels, and it looked as if the intruding vortex of the lower levels did not succeed in reaching the middle plane where theoretically the outward component begins to develop. It looked as if this vortical system was so stripped of its natural features, by the action of its intrusion into the eastward drift, that only the lower half of the vortex really survived, and that there was an insistent struggle of the rotating cyclone with this eastward drift for the mastery. In a word, the upper sections of the vortex were stripped bare, and they gradually died out at the height of three or four miles within the eastward drift. What remains then is a set of stream lines in the lower levels which have certain features in harmony with the pure vortex system, though only roughly conforming to them, and which in the upper levels is broken down into a very imperfect kind of vortex. It should be said in passing that it is very difficult, on account of the prevailing clouds which occur in the cyclones of the United States, to get satisfactory measures of the cloud motions in the upper levels. Cumulus clouds develop strongly below the one-mile level, and above them it is possible to get the cloud motions in the higher levels only through the more or less occasional rifts in the lower cloud sheets. It is therefore very desirable that an extensive campaign of theodolite measurements of cloud motions in the upper levels of cyclones be instituted, in order to carry out much more fully the details of the discussion which have been suggested in this fundamental research.

Temperature Distribution

Having now described the general and local circulations in the temperate and tropical zones, it is important to make some further remarks regarding the distribution of temperature in those regions, also including the distribution of temperature in the sun itself. The circulations which take place are accompanied by certain changes of temperature in a vertical direction, called temperature gradients, which are characteristic of them. If a cubic centimeter of air at the sea level is lifted up to higher levels, so that it cools simply by the expansion of its own mass, and there is no mixture of warmer or colder air with it from the outside, then the temperature will fall 9.87° Centigrade for every 1,000 meters. Now it is found by balloon observations that the temperature gradients in different regions do not conform to this fundamental rule, which is called the law of adiabatic expansion. In the tropics in the lower levels this rate is very nearly approached, but there

is a considerable deviation from it in the upper levels. In the temperate zones the normal vertical temperature gradient is only about 5.40° Centigrade, though it may be considerably more or considerably less according to the circumstances. It may be generally said that, except in restricted regions, the air does not cool as fast in going upwards as it should if it were caused by mere vertical expansion. The upper levels of the air are too warm; warmer than they should be if that law prevailed. In the temperate zones they are very much too warm, and that is why the vertical gradient is less than it should be according to that law. The fact is that the warm masses of air which flow from the tropics towards the poles retain their heat above what they should have for the given latitude, and in that way the upper levels of the atmosphere are maintained at a considerably higher heat than would be expected. When the air has once cooled to about 70° below zero, Centigrade, it seems disinclined to cool much further, and in the levels from 12,000 to 16,000 meters high there has been discovered a tendency for the air to be somewhat warmer than it is in the levels below, say from 8,000 to 12,000 meters high. It is generally thought that this phenomenon is due to radiation in some of its effects, but it is still a subject of discussion. If we should assume as the average vertical gradient for the entire atmosphere a rate of about 7° Centigrade per 1,000 meters then we should find that the temperatures in the tropics fall off too fast, and in the temperate zones too slow to conform to this average gradient. Now the mathematical law shows that if the lower levels of the atmosphere are relatively too warm for the upper levels there will be a westward drift as in the tropics, and if the upper levels are too warm relatively for the lower levels there will be an eastward drift as in the temperate zones. Speaking a little more broadly still, in order to avoid discontinuity, that is to say, changes by jumps in the atmosphere as regards the barometric pressure at the different levels, since the warm air has less density than the cold air, it follows that the warm air must move faster over the surface of the earth than does the cold air. Hence it is that in the tropics the air is too warm for its altitude, and it must move off faster than it otherwise would in the tropics. The westward drift in the lower levels compensates for this excessive temperature, and in the upper levels of the temperate zones the excess of motion compensates for the higher temperature. We find exactly the same principle working in the formation of hurricanes and tornadoes. Hurricanes develop in the northern hemisphere in the late summer and early autumn, and this is the season when the cool air of the northern latitudes begins to spread southward towards the equator as the sun begins its southward march into the southern hemisphere. At first the cool air flows over the warm air in the higher levels. This in a general way increases the vertical tem-

perature gradient, and induces a more lively movement in the lower levels. In certain localities, in order to keep up the vertical continuity of barometric pressure, the warm air slides out radially in all directions, where conditions are right, and this movement first induces the vortical action in the upper sections of the hurricane which is gradually propagated, when it is highly developed, to the surface. Tornadoes are formed in somewhat a similar way, but in this case the cold and warm masses lie side by side on the same level, though there is a tendency for the cold air to overflow the warm air. The sliding action of the warm air against the cold sheet is the first incentive to the curling-up process which culminates in a tornado. In the ordinary cyclones the temperature distribution is such that the vertical gradient is about the same in the cold as in the warm mass, taken separately, though there are moderate variations in the different quadrants surrounding the high and the low areas of pressure. The warm air then overflows the cold air in two branches, and the cold air underflows the warm air in two branches. This tends to induce vortical action, but as already explained it is retarded, and the development is very imperfect on account of its intrusion into the eastward drift.

While our knowledge of the distribution of velocity and temperature in the atmosphere of the sun is much less perfect than it is of the atmosphere of the earth, we have yet definite knowledge regarding several important features. Apparently the sun's atmosphere does not operate in the same way that we have found to be the method of the circulation of the atmosphere of the earth. It is quite easy to see that these two atmospheres should work in a very different way. The atmosphere of the earth is really a thin shell of air heated in one zone by the solar radiation falling upon it, and then this thin shell simply slides around over the surface of the earth according to the laws which have been described. In the case of the atmosphere of the sun we have no definite knowledge as to its depth. It is proper to infer, from the law of pressure and mass, that the density near the center is such that the interior of the solar mass consists of a nucleus in a highly viscous or even solid state. Such a nucleus may be only one third of the diameter of the sun, but as the radius of the sun is 694,800 kilometers it would make a nucleus of about 400,000 or 500,000 kilometers in diameter. Above this the shell of the sun would be something like 400,000 kilometers thick, that is, about 250,000 miles. Our observations can not penetrate below the surface of the solar photosphere, and of course it is impossible to trace out the great currents which are undoubtedly operating within this enormously thick mass. On the surface we know from various sources that at the equator the solar mass drifts from east to west as we look at the sun's disc with a velocity such that the sun turns on its axis, as we see it, once in 26.68 days. This rota-

tion of velocity falls off gradually towards the poles, until at the poles it takes something like 30 days to turn around. There is evidence to show that in the polar zones or near the poles there are certain variable velocities of rotation. These may belong to different sections in the sun's atmosphere. Our observations at the poles cut through the sun's atmosphere, as it were, parallel to the surface. At the equator our observations look down vertically through the sun's atmosphere. We can therefore near the poles get the same kind of observations at different solar levels. However this may be, the turbulence of motion seems to be much greater near the poles than near the equator. Within the sun's mass we can well imagine that many different periods of rotation, or of the daily angular velocity, actually exist. Looking at the solar surface as a unit, it consists of a huge wave whose crest advances around the equatorial regions at a considerably greater speed than in the polar regions. Now our mathematical analysis indicates that such a circulation can be maintained if the solar temperatures are greater in the polar regions than in the equatorial regions. That is a form of vortex, applicable to the solar mass, in which the velocities and temperatures are so connected together that the polar regions are warmer and have a slower angular velocity than the equatorial regions which are cooler with a greater angular velocity. This, therefore, is a condition of affairs practically the inverse of what we have been describing in the atmosphere of the earth. It is of course in some way associated with the great heat cauldron which is boiling inside the solar surface, where the heat accumulates and congests and finally works its way to the surface by means of this gigantic solar vortex. Within the great vortex there are innumerable minor vortices. These vortical tubes generally stretch from north to south perpendicular to the plane of the equator. These vortex tubes may be very irregular and broken up, but as a whole the sun may be described as a polarized mass throughout which the minor motions are nearly parallel to the plane of the equator.

Solar Phenomena

The different levels in the sun's atmosphere have received the following names: The lowest one which is visible is called the *photosphere,* and consists of mottled shapes like cumulus cloud forms, bright and dark areas being interspersed. Above this is the *chromosphere,* a layer of hydrogen and calcium and other gases 5,000 or 6,000 miles thick. The lower surface of the chromosphere is a reversing layer, so called, and is the level at which the dark lines of the solar spectrum are formed. Through these layers are projected jets of hydrogen and calcium flames which stretch out beyond the visible edge of the sun called *prominences,* and far beyond the region of the prominences

extends the *solar corona* which reaches enormous distances into space. The corona is apparently composed of minute dust particles and ionized atoms and molecules held in certain positions by the action of electric and magnetic forces. The photosphere is penetrated in certain regions by *solar spots* which extend from the upper levels of the photosphere into the interior. It has been shown by recent photographs taken at the Mount Wilson Observatory that the sun spots are closely associated with motions so like those pertaining to the sections in a dumbbell-shaped vortex that the analogy appears to be very complete. If this is so, then terrestrial meteorology becomes intimately connected with solar meteorology in many of its features, in spite of the great differences of temperature. The average temperature of the earth's atmosphere may be taken as about 15° Centigrade below zero. The surface of the photosphere is apparently between 7,000° and 8,000° Centigrade, and the sun's temperature increases to more than 10,000° near the nucleus, though the gradient is not yet known. Taking the sun spot region as a whole, the sun spot belts form near latitude 30° north and south of the equator and they gradually drift towards the equator in the course of about eleven years, when new spot belts begin to form. The same is true of the faculæ which are closely associated with sun spots. The circulation within the sun spot belt is from the surface downwards, while the spots drift as a whole towards the equator. This indicates, therefore, descent into the sun from the surface in the neighborhood of the equatorial regions, and, of course, to compensate this, material must be projected from the interior outwards in the higher latitudes.

The *prominences* are hydrogen flames going through a periodic drift. They may be said to appear first in largest numbers in middle latitudes, and they seem to divide into two branches so far as the number of them is concerned. One branch drifts southward in the eleven-year period along with the spots and the faculæ. The other branch drifts poleward to the north and to the south, respectively. A study of the number of these prominences in different latitudes indicates that there is a periodic change in the apparent velocity of the rotation in the polar regions, fluctuating back and forth in about a mean value. Since the prominences have different elevations, and different levels in the sun have different velocities, it may well be that in the polar regions the prominences develop sometimes in the higher levels and sometimes in the lower levels, so that they actually drift eastward at different angular velocities according to their elevation. The spectroscope apparently indicates a certain angular velocity pertaining to special spectrum lines, which look like a fixed value for a given elevation, and at the same time it has been shown that hydrogen

lines have different values from iron lines, and therefore the entire subject is open to an extensive investigation.

The atmosphere of the earth is filled with what is called *atmospheric electricity.* This consists of positive and negative charges of electricity distributed in a very complex way, depending upon temperature, vapor contents and barometric pressure. The distribution of electricity changes with the season of the year, and with the hour of the day, and differs from latitude to latitude, and from elevation to elevation above the same place. Similarly the sun's atmosphere is filled with electric charges. Every electric charge in motion produces magnetic field. If particles of electricity rotate about an axis, and parallel to a given plane, there will be a magnetic field perpendicular to that plane. These magnetic fields may occur at any temperature, provided the charge of electricity and the motion in a closed curve is at hand. If a ray of light in a strong magnetic field is looked at along the lines of force of the field, a single ray is split up into two lines slightly displaced and circularly polarized in opposite directions. If the line of light in the magnetic field is looked at perpendicular to the lines of the magnetic force, a single is split up into three or more lines. In the case of three lines the outside lines are displaced and polarized in one direction, while the middle line is not displaced but is polarized at right angles to the two side lines. These effects of the magnetic field upon a ray of light are called the *Zeeman effect,* and if these effects are seen it is strong evidence if not proof that the magnetic field has been acting upon the ray of light. The Mount Wilson Observatory has been able to show that the light which comes from the interior of the sun spot or vortex produces both types of the Zeeman effect, the two circularly polarized lines when one looks at the spot near the center of the solar disc; that is down the tube of the vortex; and the three plane polarized lines when one looks at the sun spot near the edge of the sun, that is, nearly at right angles to the sun spot vortex tube. At any rate enough has been shown to make it more than probable that magnetic field exists certainly in the solar spots, and probably throughout the mass of the sun where gyrations and internal vortices doubtless take place. If the sun spot produces a magnetic field strong enough to show the Zeeman effect at a distance of 93,000,000 miles, it is entirely reasonable to suppose that magnetic fields occur through the solar mass wherever there is actual circulation. It has already been intimated that the entire body of the sun consists of an enormous number of circulating tubes directed more or less perpendicular to the equator, and as a corollary the entire mass of the sun would be a magnetized sphere. The ends of these polarized circulations at the solar surface should develop an outside magnetic field to correspond with the interior. In my early researches of nearly twenty years ago it was shown that the lines in the

solar corona are so distributed, especially at the time of minimum sun spot activity, as to indicate strongly that they were arranged around the *sun as a magnetized sphere.* It is not necessary here to review the many details which pointed to that conclusion. The great objection to that theory at the time in the minds of scientists consisted in the fact that the sun was too hot to be a magnetized sphere. It was pointed out by me that the earth is certainly a magnetized sphere, and that its interior has a very high temperature. Since those days the discovery of the ionization of matter, whereby dynamic forces of one kind or another disintegrate the atoms, of which molecules are composed, into their primal constituents, which are pure charges of electricity, and the demonstration that the free ions, positive or negative, as the case may be, wander about from place to place and produce magnetic field, have made this theory of the sun much more intelligible. The additional discovery of the Zeeman effect of magnetic field in the sun spots greatly strengthens my theory, and in fact it is not easy to see how solar phenomena can now be discussed on any other general basis.

The solar output shows itself in an irruption of prominences, in a very extended corona, and in an *invisible radiation* stretching out to almost unlimited distances in space. The polar magnetic field of the sun, of which the corona is an evidence, will expand to great distances from the center, and its strength may perhaps be detected as far as to the distance of the earth. Electromagnetic radiation stretches out over the solar sphere radially in every direction, a small pencil of the same falls upon the earth in its different positions along the orbit from day to day, and sets the circulation up in the earth's atmosphere which has been described. This solar radiation falling upon the earth's atmosphere is in part absorbed by it, so that the molecules and atoms yield up their ions, which by redistribution produce the observed phenomena of the earth's electric field, and also certain well-known variations in the strength of the earth's magnetic field. The entire subject is full of difficulties, but at the same time it possesses a fascination to the student such as pertains to very few branches of modern science. This same radiation of the sun falling upon the earth produces the temperatures which vary from place to place, from season to season, and from year to year, in a very complex series of changes which, taken as a whole, constitute what is called the earth's climate. There are many indications that this solar radiation, that is to say, the electromagnetic energy which the sun sends forth into space, is not exactly constant. The sun seems to be a variable star, the variation in its heat and light is the natural consequence of the incessant changes of temperature and pressure, in the circulation, the electricity and magnetism, which are going on within the solar mass. We have already been able to show from our studies of the barometric pressure, temperature and vapor pressure in

different parts of the earth, especially of the United States, that there is a definite though complicated synchronism, which connects the variations of the solar action with the variation in the terrestrial climatic effects. This is a large subject which can not be properly undertaken in this lecture. It may be said in general that as the sun gets more energetic in some parts of its period, the temperatures in the earth's tropics are higher, and simultaneously in the temperate zones they are lower. At the same time the barometric pressures in the atmosphere of the earth centered around the Indian Ocean are higher, while in North and South America they are lower. In the Pacific states the temperatures increase with the solar energy, and in the central and eastern states they decrease. The solar impulse which produces these effects tends to precede the terrestrial exhibit which depends upon the solar impulse by some months, possibly by a year under certain conditions, and this anticipation of course promises an opportunity to develop what may become a rational ground for a seasonal forecast for terrestrial weather. The entire field of operations is very complicated, the circulation in both atmospheres tends to mask and make more complex the pure variation of the solar radiation, so that we must be very cautious in attempting to pronounce for or against certain tentative conclusions regarding this subject. It will probably require more than one generation of men to make practicable and popularize the result of this research. Mathematicians as well as laymen are cautioned to withhold negative evidence based upon half understood phenomena, because it is in fact very difficult to disentangle the net which nature has spread before us. The threads should not be torn and distorted by the bungling hands of those who have not the training required to unravel the several skeins which lead to the center of the great mesh. It is certainly not saying too much to assert that there is good ground for proceeding positively and firmly along this line of research, and the fact that it has attracted the attention of many commissions, international committees, scientific societies, observatories and institutions shows to what an extent the great problem has already commended itself to the favor of scientific men.

THE REORGANIZATION OF AMERICAN FARMING

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FROM the beginning, American agriculture has been characterized by its extensiveness rather than its intensiveness. Land has been more abundant than labor and, in the aggregate, more has been derived from a small yield on a large acreage than could have been realized from a large yield on a small acreage. The yields of American farm crops have been proverbially small, but the total production has been exceptionally large and, as a rule, the countries producing the largest amounts of farm crops have the smallest yields per acre. This fact is illustrated in the following table:

Table showing the Average Yield of Wheat per Acre by Ten-year Periods for the last Twenty Years and the Total Production for 1908

	Avr. Yield per Acre, 1888-97	Avr. Yield per Acre, 1898-1907	Total Production
United Kingdom	30.1 bu.	32.6 bu.	55,585,000 bu.
Germany	22.7	28.4	138,442,000
France	17.6	20.8	310,526,000
United States	12.8	13.9	664,602,000

The above table also reveals the fact that the production per acre when compared by ten-year periods has been increasing in all the countries. Much has been said and is being written about the decline in agricultural production, but statistics do not show that there has been any decline, but rather a marked increase when the productions of the leading countries are compared and using the production of wheat, which is the most universally grown farm crop, as the basis for comparison.

The intensity of culture always bears a direct relation to the density of population and while it is difficult to get a comparable basis of comparison between countries on account of the varying proportions of waste land in different countries and different methods of classifying statistics, the following table represents the most reliable figures available and, when compared with the preceding table, shows that the yield of wheat per acre varies directly as the density of population.

Number of Acres per Capita

United Kingdom	1.70 acres.
Germany	2.37 acres.
France	3.40 acres.
United States (exclusive of Alaska and Philippines)	24.02 acres.

In 1900 there were 838,000,000 acres in farms in the United States, and since then we have been adding to them about 15,000,000 acres each year from the public lands of the country. During this time, however, the population of the country has been increasing at the rate of about one and one half million each year. The public lands of the country that are suitable for agricultural purposes have practically all been taken up; the tide of immigration has been turned back from the Pacific coast, and the competition for land already under cultivation has become much more keen and, as a consequence, the values of farm real estates have advanced generally throughout the country, but to the greatest extent in the western states. Farm lands in some sections have doubled or even tripled in value in the course of a few years.

Together with the increased value of farm lands have gone other changes that have had an important bearing on the agriculture of the country.

The development of methods of transportation and the extension of railroads through the new agricultural lands have widened the markets of the country, for both buying and selling. The introduction of refrigerator car service has made possible the shipping of fruits, meats and other perishable products across the continent. This has resulted in bringing the products of cheap lands in competition with the products of high-priced land in the eastern states.

Another factor that has had an important bearing in this connection has been the development of labor-saving farm machinery. If the present wheat crop of the United States were harvested by the method employed at the time of the civil war, it would require every man of military age in the United States to work for at least two weeks in wheat harvest. The invention of labor-saving machinery has increased the producing power of the individual to such an extent that notwithstanding the increase in the agricultural exports of the country from $205,853,748 in 1858 to $1,017,396,404 in 1908, the percentage of the population engaged in agriculture has decreased by decades as follows:

1880	44.3 per cent.
1890	37.7 per cent.
1900	35.7 per cent.

But notwithstanding the constant decrease in the proportion of the population engaged in agriculture, the per capita production for the entire population of the most important classes of agricultural products has increased almost invariably.

The following table gives the average per capita production by decades, 1866–1908. These statistics are from the United States Department of Agriculture:

	Decade				Period
	1866–1875	1876–1885	1886–1895	1896–1905	1905–1908
Wheat, bushels	6.2	8.3	7.4	7.8	7.9
Corn, bushels	24.6	30.3	27.5	28.4	31.8
Oats, bushels	6.9	9.1	10.7	10.6	9.8
Barley, bushels	.7	.9	1.1	1.3	1.9
Rye, bushels	.5	.5	.4	.4	.4
Potatoes, bushels	3.0	3.0	3.0	3.1	3.4
Cotton, pounds	37.8	51.4	57.8	65.5	70.0
Hay, tons	.63	.76	.86	.76	.74
Horses, number	.20	.21	.23	.20	.23
Milch cows, number	.25	.24	.25	.22	.24
Other cattle, number	.37	.47	.55	.49	.55
Swine, number	.69	.75	.73	.58	.64
Sheep, number	.80	.84	.68	.63	.64

This almost inconceivable increase in agricultural production has been accompanied by changes in agricultural conditions that make a reorganization of American farming methods absolutely necessary.

Foremost among these changes has been the growth of cities from an urban population of 2,897,000, or 12.5 per cent. of the population total, in 1850, to a population of 24,992,000 or 33.1 per cent. of the total population in 1900. This concentration of the population has brought about new problems of food supply in furnishing the more perishable products such as milk, vegetables, fruits and such products as need to be consumed soon after production.

Another condition that has arisen is the tendency of the soil fertility of the farms of the older agricultural sections to become exhausted. To remedy this, the use of commercial fertilizers has become general in eastern United States and the statistics of 1900 show that $55,000,000 worth of goods were used by the farmers of the United States, which was an increase of 42 per cent. over the amount used in 1890, so that it is probable that not less than $75,000,000 per year is spent for this purpose.

The opening up of the middle west took from the farmer of the eastern states his market for wheat and other grain. He was thrown in competition on the open market with the farmer who had secured his land for practically nothing and land that was much more fertile and productive. The farmer of the middle west, in turn, has been thrown in competition in the live-stock markets with the live-stock products of the western and southwestern states and territories. Stock that was raised under range conditions and often on government land free of charge competed with stock raised on high-priced farms of the middle west.

While these conditions are not so emphatically true as they were a few years ago, yet the problem is far from being solved and the American farmer is now passing through a transitional stage and the most

important problem before him at the present time is the question of reorganizing his farming methods so as to best fit the agricultural conditions as they now exist.

The unprecedented increase of values of farm products in recent years resulting in a greatly increased cost of living to every one has resulted in the most prosperous times the American farmer has ever experienced, except during the civil war by those who stayed at home and reaped the benefits of high prices.

The consumer, on the other hand, is alarmed at the continued rise in price of the necessities of life. He is interested in knowing what the end is going to be and how much longer prices are going to rise.

Writers who are ill-advised of the potential producing power of American farms are freely predicting that we are rapidly approaching the time when as a nation we shall not be able to produce sufficient food stuffs for our own population. They forget that our farms are not producing more than one half of what they are capable of doing. Our average wheat yield is 14 bushels per acre; our average yield of corn is 26 bushels, and of oats, 25 bushels; these yields can and will be redoubled in the future as the high price of the products will demand.

The profits of farming in the past gained from actual production has not been in proportion to the profits derived from other industries. The market price of farm products has tended toward the actual cost of production of the average crop at current wages rather than the cost of production of the part of the crop produced under the most unfavorable conditions. This is readily demonstrated by taking the actual amount of time required to grow and harvest an acre of any of the principal crops and calculating the time at current wages and the average yields at farm prices.

The results will show that the returns received for the time spent will not be more than enough to pay current wages and six per cent. interest on the investment in land and equipment. Farmers have received greater returns from the increased value of their lands than they have from the profits upon their productions.

The increased prices of farm products are beginning to bring to farmers a just return for labor expended and will do more than anything else to turn the city dweller "back to the soil" and to keep the country boy on the farm. There is no danger of a shortage of food supplies in this country, but higher prices must prevail in order to develop the potential agricultural resources of the country. Aside from the possibilities of doubling the present crop production on present area under production, there remains the undeveloped agricultural lands of the country. Aside from the limited amount of land suitable for agricultural purposes still remaining in the ownership of the government, the lands that may become valuable for agricultural purposes are of

two kinds—the swamp lands that may be reclaimed by drainage and the arid lands that may be reclaimed by irrigation. The United States Geological Survey estimates that75,000,000 acres can be made valuable for agriculture by draining swamps. This is the equivalent of one sixth of all the land now under cultivation in the United States. This land would be much more fertile and much more productive than the most of the land that is now being cultivated. The reclamation of arid lands is just in its infancy. The first federal act to provide for government assistance for this purpose was passed in 1902.

Projects are now under construction or have been completed that will reclaim one and a half million acres and others are under consideration that will reclaim three and one half million. To what extent this work of reclamation will be carried in the future can scarcely be estimated, but doubtless many millions of acres can be and will be added to our cultivable lands in the future.

The period of low prices for farm products and extensive methods of farming is rapidly passing. The large grain and live-stock farms of the eastern states are giving way to the smaller dairy, fruit, vegetable or poultry farm. The large wheat farms of the northwest are being divided into moderate-sized farms for mixed farming. The ranges of the west and southwest are being broken up into stock farms and the movement everywhere is toward more intensive methods of farming.

The problem that now confronts the American farmer is to reorganize his method of farming so as to adapt it to the present conditions. The increased prices for farm products will increase their production and insure a supply sufficient for all needs for the future.

INSECTS AND ENTOMOLOGISTS, THEIR RELATION TO THE COMMUNITY AT LARGE. II

By Professor J. B. SMITH
RUTGERS COLLEGE, NEW BRUNSWICK, N. J.

AND now, having given a very hasty and superficial statement to show how important a place the insect really occupies in the social economy, it behooves me to say something of some of the men whose labors made some of these facts and conclusions known.

Many of the matters of which I have spoken are of recent development and the men who have done the work are still with us and still working. Some are in attendance at this very meeting and as we expect still better work from them, nothing will be said of what they have done thus far. And while it is intended to confine the mention to American entomologists, it is necessary to include under that head some whose claim to be called American rests altogether upon the work done with or on American insects. Let me say too that the order in which the names come is not meant to represent anything more than convenience in arrangement of topics, and finally, it is not to be understood that omissions show lack of regard, but only that within my time limit no photographs were obtainable.

Thomas Say has been termed the father of American entomology, and certainly no one is better deserving of that term than he. He builded well and broadly and his knowledge of the American insect fauna was surprising. His work was in all orders and the amount of material that passed through his hands was very large. Unfortunately most of his types have been destroyed, so that we are not now able to see the specimens that he had to work with. This has made less trouble than with some other authors, because Say had that wonderful faculty of seizing upon and describing the specific peculiarity of the individual before him. I well remember the hours that I spent over his descriptions, trying to identify captures made thirty-five years ago, and while I was often disappointed, I succeeded in correctly identifying what I now consider a really large percentage of the forms taken. Say's experience meant hard work under difficulties: no money—very little literature. His bed, for a time, the floor of the Exhibition Hall of the Academy of Natural Sciences in Philadelphia, his food costing six cents per day. Encouragements there were few—discouragements many and none greater than the lack of literature. None of the younger men can appreciate that hunger for books with which the older men were compelled to fight and the enjoyment of getting into an alcove with

GEORGE H. HORN

SILAS S. HALDEMAN

JOHN L. LE CONTE

BARON R. VON OSTEN-SACKEN

THOMAS SAY

THADDEUS W. HARRIS

WILLIAM H. ASHMEAD

HERMANN LOEW

H. A. HAGEN

volumes that you knew were in existence but had never before seen. And yet Say was well off in these matters because he had the library of the academy to draw upon, and there were then—possibly there are now—more works on entomological subjects in Philadelphia than elsewhere in the United States.

MELSHEIMER AND HALDEMAN were also of the Philadelphia clan, coleopterists and systematists, and to the former we owe the first catalogue of American coleoptera—an excellent piece of work for its time and of very great use to students until it was superseded by the Crotch check list, which remained the standard for many years until it in turn was superseded by the Henshaw list. These latter check lists are both the work of the Boston circle, Crotch having done most of his work at Cambridge, where Henshaw is still doing excellent service.

DR. JOHN L. LECONTE, of Philadelphia, has without doubt done more for American coleopterology than any one other man. It was my privilege to know him personally and to profit to some extent by his encouragement and advice. Dr. LeConte, though confining his work to the coleoptera, was by no means narrow in his knowledge, and the comprehensive view that he was able to take of his subject is witnessed in the "Classification of American Coleoptera," which forms to the present day the basis of our knowledge in this order, and which will maintain its value though the order of families may be changed and their relationships better established. Dr. LeConte's collection is now at Cambridge, accessible to all serious students.

DR. GEORGE H. HORN, first a pupil, later a collaborateur with Dr. LeConte, did as much or even more systematic work in coleoptera. But the work is different: Dr. Horn was a genius in the separation of species and in their arrangement within generic or family limits; but he lacked the broad views of Dr. LeConte and was more precise in working out details. With Dr. Horn I was well acquainted, and many an hour did I spend in his room among his boxes, while he was on his rounds; for the doctor had a large practise and entomology was his recreation. I regret that I can not give a picture of that room. There was a cot in one corner which was often the only available place to sit; there was a huge table or desk occupying most of the floor and, during the many years that I knew that room, this table was cleared only once. Occasionally the cigarette stumps would be gathered together and thrown out; but the dust and dirt were never otherwise disturbed. Cabinets and book-shelves were about the walls and books were everywhere—on the floor, the chairs and often even on the bed. It was strictly a workroom and the doctor was an indefatigable worker. His collection is now in the rooms of the American Entomological Society in Philadelphia.

JOHN ABBOT, associated with J. E. Smith in the work on the rarer

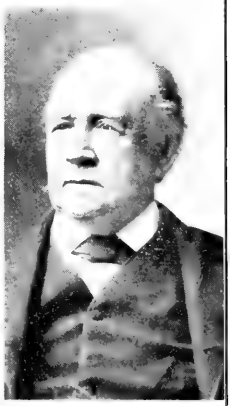
WM. H. EDWARDS

HENRY EDWARDS

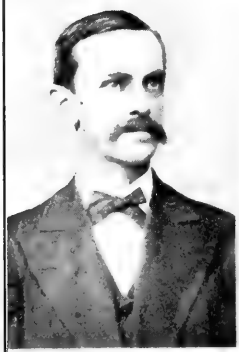
BRACKENRIDGE CLEMENS

HERMAN STRECKER

SAMUEL SCUDDER



J. G. MORRIS



GEORGE D. HULST

AUGUSTUS R. GROTE

JOHN ABBOTT

lepidopterous insects of Georgia, is an example of the combination of artist and entomologist, and his *published* drawings give no idea of the amount of the work he actually did, nor any real idea of its beauty and accuracy. There are bundles of unpublished drawings in the British Museum, a few of them in the Boston Society of Natural History, and others scattered about. Some of the insects figured have never been found since; some, described from the figures by Guenée, Boisduval and others have never been satisfactorily identified, and I well remember my hunt through Paris, over twenty years ago, under the guidance of M. Aug. Sallé after the original of one of Boisduval's descriptions, which was finally located in the possession of a former housekeeper, who fell heir to some of the effects of her master.

A hale, hearty old man was Dr. J. G. Morris, of Baltimore, when I first met him thirty years or more ago, and never was I more pleased to meet any one because, somehow, I had received the impression that he was dead. Dr. Morris made the first attempt to gather together the descriptions of American lepidoptera, and his volume in the Smithsonian series proved a very useful one to the collectors of that day. Unfortunately the scheme was never completed, and a very small section only of the Heterocera is represented in the volume. Dr. Morris did not, I believe, ever describe either genus or species, and never pretended to any extensive collection.

A. R. Grote, of Buffalo, and later, New York, was a most earnest worker in the heterocerous lepidoptera and chiefly in the Noctuidæ. To him we owe the first satisfactory arrangement of our species, and the identification of the species described earlier by Guenée and Walker. It was no light task, and how remarkably well done it was I did not realize until years thereafter, when I undertook similar work. Mr. Grote's collection is now in the British Museum, where I have had the opportunity of comparing its types with those of Walker and Guenée which are also in that rich treasure house.

Mr. W. H. Edwards, of Coalburg, W. Va., I never met, although his death is comparatively recent. But his magnificent work in the butterflies lives on, and will continue to live. Mr. Edwards was much more than a describer of genera and species. He was a real student of the life of the insects, and he did more to make known their early stages than any one other worker: and besides, he set up a standard of thoroughness and accuracy, that our younger students must live up to if they expect their work to be regarded. His collection is now in the Carnegie Museum, at Pittsburgh.

Mr. Henry Edwards, of New York City, was one of the centers of entomological interest in that city—hearty, whole-souled, enthusiastic. He made friends wherever he went and his travels carried him not only throughout our own country, but into Australian and Asiatic countries

as well. He was an excellent collector and his cabinet was unusually rich in Californian and Pacific coast forms. This collection remains in New York, and forms the nucleus for the lepidoptera in the collection of the American Museum of Natural History.

Dr. George D. Hulst was one of the Brooklyn entomologists and devoted his energies to work in the lepidopterous families Geometridæ and Pyralididæ. While his systematic work in these groups is most useful, it is not equal to his personal influence upon those that were fortunate enough to come into contact with him. I grew to love that man and felt his death as a personal loss. His collection is now in my charge at Rutgers College, to which institution it was given by him before his death.

Dr. Herman Strecker, of Reading, Pa., was known to many of our older members, and never were there more diverse judgments than those passed upon him. But he was earnest if erratic, and succeeded in accumulating an enormous collection of lepidoptera during his long life. He would pay any price for a specimen that he wanted, and halt at no expedient to secure what he could not buy. He was a genius with pen, pencil and chisel; a sculptor of mortuary emblems by profession, and a painter of butterflies by choice. His publication on this subject was unique: all the drawings and engravings were made by him, and all the plates were hand colored. His industry was continuous and he was tireless in his work. His writings were spicy and he never hesitated in printing what he wanted to say: he was his own publisher and had none to say him nay. His collection is now in the Field Museum in Chicago.

In the tineid families of the Microlepidoptera there was an immense untilled field which only one of the older American students had the courage to undertake. To Brackenridge Clemens belongs the honor of breaking ground in this series, and upon his work the subsequent students in the group, whom fortunately we yet number among our associates, have built their own. Clemens also did some work in the macros, notably the Sphingidæ, and many of his types are yet to be found in the collections of the American Entomological Society.

Among the unique figures in American entomology none looms larger than Dr. H. A. Hagen, of Cambridge. Big, ponderous, thoroughly German to the end of his life, intensely loyal to his chief and his work, he was easily the most learned entomologist of his day. His monumental work in the literature of entomology has proved a gold mine for later students, and would alone have been considered a creditable life work. But Dr. Hagen was also a special student in the Neuroptera, and his volume in the Smithsonian series is essential to every student in the order to the present day. I knew Dr. Hagen well and was his guest at times. I won his heart by the meekness with

which I accepted a severe reproof concerning a sending of diptera for determination. He had kindly replied to a letter of mine asking for aid and, in return, I had packed a cigar box as full as it would hold of undetermined specimens, big and little. I got it back next mail, and with it a letter. The letter was instructive, very—and if the medicine was bitter, it was at least salutory for I never did the like again, and have never dealt quite so hardly as I might with those who have in later times imposed upon me, as I did upon Dr. Hagen. His library and his collections are at Cambridge, and no one who has not seen both can appreciate the amount and character of the work that the good doctor did during his lifetime.

Baron von Osten-Sacken was an unusual combination of diplomatist and entomologist. Of his standing in the former capacity I know nothing; as a dipterist none stands better. To him we owe the early systematic work done in this country and the series of volumes published by the Smithsonian Institution, for even the work of Loew was made available through translation by Osten-Sacken. And so these two pioneers of American dipterology must almost necessarily be considered together, although the influence of Loew could not be so great because of his dependence on a translator in reaching the American public. Shortly before his death Osten-Sacken published his memoirs, which certainly make interesting literature. A large part of his collection is in the museum at Cambridge.

Among the hymenopterists I can mention only William H. Ashmead, whose death is so recent that most of us remember him personally, and whose gentle manner and unfailing courtesy endeared him to all who came into contact with him. His work was monumental and his systematic sense so developed that he seized almost at a glance upon the really essential structures of the species studied by him. So constant and persistent a worker was he that, to those of us who knew him personally, the surprise was not that he died so young, but that he lived so long.

Dr. A. S. Packard, of Brown University, was more than an entomologist: he was a biologist and a teacher. His work as a systematist was great; but as a teacher he was greater. And his teaching was not confined to the classroom; his "Entomology for Beginners," his "Guide to the Study of Insects" and his "Text-book of Entomology" continue his work, though his voice in the classroom is hushed. His interests were broad enough to include even the economic side of the subject and he appeared as a member of the U. S. Entomological Commission, though his part of the work was that which was more technical in the publications.

I can scarcely avoid referring at least to Dr. S. H. Scudder, although he is yet with us, not only because his work, unfortunately,

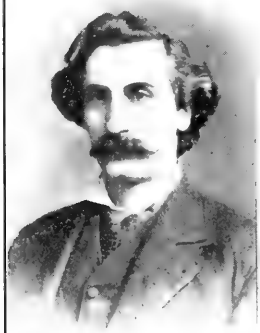
WM. LE BARON

J. A. LINTNER

TOWNEND GLOVER

A. S. PACKARD

JAMES FLETCHER



C. V. RILEY

ASA FITCH

B. D. WALSH

is done; but because it was carried into fields not theretofore frequented by American entomologists. His labors on the fossil insects of America are unique, and his collection of material for further work is immense. Of his systematic papers on orthoptera and his accomplishments in other directions I will not speak at present.

All these men paved the way—they made the studies necessary to familiarize us with the insects round about us, and theirs is the labor that is not spectacular and whose apparent results are not of public interest: yet such work we must have as a foundation for what we consider the more practical side of the subject.

First among the economic entomologists of this country we must reckon Dr. Thaddeus William Harris, whose work on the "Insects Injurious to Vegetation" is a classic and, like most of the classics, was a labor of love rather than a money-making proposition. The state of Massachusetts paid him $200 for that work. Since that time it has learnt to pay rather more highly for entomologists, and nowhere have insects done more injury nor have they anywhere demanded the expenditure of greater sums. Harris's work is not only intensely practical, but it is interesting and informing—as useful to the beginning collector and entomologist as to the agriculturist, and always accurate.

Quite a different sort of man was Townend Glover, for a series of years entomologist to the U. S. Department of Agriculture, who wrote comparatively little, but used his pencil industriously; producing a perfectly enormous number of drawings of insects in all stages, and engraving them on plates from which only a very few impressions were taken. Unfortunately, Glover had almost no systematic knowledge of insects, and while he made excellent pictures of the specimens as they appeared to him, he had not the slightest idea as to the identity of the insects figured, nor did he preserve the originals.

Dr. Asa Fitch, of New York, was a man of different type. A hard worker and hard student, industrious, of course, he studied not only those species that his field work demonstrated to him as injurious, but their allies and neighbors, and with a sure glance he fixed upon certain of the hemipterous families as entitled to the special consideration of the economic worker. Dr. Fitch's reports as state entomologist initiated a work in that state which has not been abandoned since, and which has put it among the leaders in organizations for entomological work.

Meanwhile, in the middle west the ravages of insects had developed new needs and new workers, and Walsh, Riley and LeBaron, began to make themselves felt, and really to develop a science of economic entomology.

Benjamin Dann Walsh, of Illinois, had a career much too short, and it terminated before he had more than shown his vigor and orig-

inality. In company with Riley, then a young man, he had planned much in the way of entomological work; but one report and a few vigorous papers in journals form the total of what remains to us.

Dr. William LeBaron, his successor in office, was a much less positive character, but an equally conscientious worker, and, in his fourth report, began what was intended to be a popular treatise on the insects, the systematic portion forming a sort of supplement to the specially economic portion. Illinois is another of the states which has never allowed its service to deteriorate, and there is no better work now done in the United States, nor is there a more effective organization than that within its limits.

Dr. Charles V. Riley was a prime factor in the development of economic entomology in the United States. His series of reports on the injurious and other insects of Missouri is a model which has never been exceeded in interest and value. Not the least important feature of these reports is the list of illustrations—wood-cuts most of them—that have never been surpassed in their fidelity to nature, and their artistic merit. Most of the insects figured in Riley's reports *look* natural, and that is the highest praise that can be given to any figure of this type. So well done are they that they have become common stock and are used again and again in bulletins and reports throughout the country. With his transfer to Washington his field of activity was enlarged, and he became a force in the development of the practical side of entomological work. The real development of our present battery of spraying outfits, arsenical poisons and kerosene emulsions began under Riley, and the fight to secure their adoption was a more difficult one than is understood. Congress thought itself very liberal when it reached the $20,000 mark for the division of entomology, and when we consider the force of men that Riley gathered and trained for that sum, men who form the nucleus of the division to the present day, we begin to appreciate the ability of the man.

I will not attempt to give a list of the men who were associated with Dr. Riley in the development of his office at Washington; I knew them all and worked with some of them for a time. And not the least of Dr. Riley's ability was in getting all that there was out of his assistants, in commanding their devotion and loyalty, although he constantly quarrelled with every one of them. He was the best loved, best hated, most admired and most detested man I ever knew; but he was always a better friend than he was an enemy, and never lost an opportunity to do a man a good turn even when he personally lost by it. Economic entomology owes much to Dr. Riley and his influence is still with us. I need hardly say that his successor has fully maintained the standard set for him, and that there is nowhere in the world at the present time a more efficient body of workers in economic ento-

mology than that connected with the U. S. Department of Agriculture at Washington.

Dr. J. A. Lintner, who was for many years state entomologist of New York, was a model of gentle, persevering labor. Quiet and deliberate in manner, very painstaking in his work and observations, he maintained the high standard set for his office by Fitch, and his reports are models of completeness in the treatment of the subjects contained in them. He was a familiar figure at the meetings of the American Association for the Advancement of Science, and was always listened to with respect.

Last of all in this list of those who have been influential in the development of the fight against insect pests, because his loss is one of the more recent, is Dr. James Fletcher, of Ottawa, Ontario. Who of the entomologists attending the annual meetings of the American Association does not remember his hearty and cheering presence. Who does not remember his cordial greeting, his constant good nature and the directness and convincing qualities of his contributions to our discussions and debates. As for the work that he did in Canada —none could have done it as he did. He was widely informed, not a narrow specialist, he was a student of men as much as of insects, and he commanded the confidence of his constituency. It will take two men or more to carry on the work that this one did alone.

To summarize—insects are a factor of very great importance in the community: (1) because of their injuries direct and indirect; (2) because of their benefits, also direct and indirect, and millions of dollars annually are involved on both sides of the ledger.

The entomologist who studies these insects, determines which are harmful and which are beneficial, who works out their life histories and habits and who determines methods of controlling those that are harmful and improving those that are beneficial, is a worker of high importance to the community and deserving of every possible aid and assistance.

ANCIENT CLIMATES OF THE WEST COAST

By Professor JAMES PERRIN SMITH
STANFORD UNIVERSITY

WE naturally look at things from the standpoint of the present, and regard the existing distribution of climates as the normal one. But even in our own times there are slight fluctuations of climatic conditions, for we hear wonderful stories from our elders of cold winters and hot summers, and tremendous storms of former years. The advances and retreats of existing glaciers give us surer testimony of recent fluctuations in temperature and moisture, as does also the shifting of the zones where wine grapes can be grown successfully in Europe.

If we go still further back into older history we find still stronger evidence of change, for in northern Africa and in central Asia there are remnants of ancient cities, evidently the flourishing capitals of prosperous peoples, where now is nothing but desert, and where even the most advanced modern skill in irrigation could not support the population of the old days.

And yet all the changes alluded to above may be only the secular variations in climate that we know are going on all the time. The climatic changes of the west coast which will be described in this paper are older than those fluctuations recorded in history, and much greater.

The old geological theory was that the earth cooled down slowly from the poles toward the equator, and that life first appeared at the poles. It was further thought that in the more remote geologic ages the interior heat of the earth was so great that there was little difference in temperature between the equator and the poles, and that, until Tertiary time, there was no differentiation into climatic zones. The Glacial epoch was supposed to be the culmination of this secular cooling off of the earth.

Then came the discovery of the old Tertiary fossil floras of Siberia, Alaska and Greenland, with abundant forests of trees that evidently lived in a temperate climate where it is now arctic. This was so remarkable that geologists had to invent some extraordinary explanation for the phenomenon. They rose to the occasion and invented the theory of the obliquity of the poles in early Tertiary time, to account for the warm temperature under the arctic circle. This, however, did not agree with the known distribution of life at that time over the rest of the earth, and also the physicists declared this obliquity, or any obliquity, to be a mathematical impossibility.

Later it was discovered that there was a great glacial epoch in the

late Paleozoic era, about the line between Carboniferous and Permian, and that too in the regions around the Indian Ocean, where it is now tropical or subtropical in temperature.

Before we had entirely recovered from the shock of that discovery, it was found out that in China and Australia there was another glacial epoch, or epochs, near the beginning of Cambrian time. Now the geologist's spirit is so broken, that when the supposed discovery of glacial epochs in Silurian and Devonian time is announced, he hardly raises a dissenting voice, and appears to be resigned to the occurrence of glacial epochs at almost any time in the history of the earth. The theory of ancient climatic uniformity is definitely abandoned, and we must accept fluctuations of climate from the earliest geologic record all through the history of our planet. The old idea was delightfully simple, but too good to be true.

Criteria of Ancient Climates

Physical Criteria.—Physical evidence as to ancient climatic conditions is limited to two classes—glacial deposits and ice-work, and sediments indicating desiccation, that is, saline and gypsiferous beds. These are both necessarily limited to continental areas, and tell us nothing of marine conditions. And as we go back in time they become more and more indefinite, so that there is much difference of opinion as to their value. The evidence of the recent Glacial epoch is positive enough to satisfy the most critical, but geologists are not yet united as to the glacial epochs in older periods of geologic history, because of the difficulty of determining whether the ice-masses were true sheets or whether they were mere local highland glaciers.

Also the sedimentary deposits indicating desiccation may have been merely local, and although they are positive as to prevalence of evaporation at that particular place, they can not tell positively of wide-spread dry climate, and certainly they do not indicate temperature.

Organic Evidence.—Fossil remains of animals or plants known to have lived in either warm or cold climates are more definite, and tell us equally well of land and water conditions, but they are authentic only when the fossils are animals or plants that have either lived on into our own time, or when the groups to which they belong have always had the same habits. This becomes more and more conjectural as we go back in geologic history, and have to deal not only with extinct species, but even with extinct genera, families and orders.

Extensive fossil beds of deciduous trees point to moist climates, and usually to temperate conditions. But deciduous trees extend back only to the middle of the Cretaceous, and beyond that time we have no positive criteria for temperate climate.

Cycads and palms are the best evidence as to tropical climates on

the land. At present, cycads are almost exclusively tropical, ranging outside only a short distance in eastern Asia. Palms are not quite so delicate, ranging outside the tropics to 34° N. lat. on the west coast of America and to 36° N. on the east coast. But in any case, abundant remains of either point to tropical or subtropical conditions.

Reef-building corals are even more definite in their testimony concerning tropical temperature of the water. They are now found only in the tropics, where the winter temperature does not fall below 68° F. (20° C.), and in general between 26° N. and 26° S. But since this temperature zone may be extended by marine currents, coral reefs may sometimes reach beyond 26° N. lat., as in the Bermudas, but more often they fail to reach this geographic limit, as on the west coast of America.

The principal reef-builders, the Madreporidæ and the Astræidæ, are confined to the hottest part of the tropical belt,[1] within 18° of the equator, and where the temperature does not fall below 74° F. (23° 20′ C.). Between this line and the isotherm of 68° F. coral reefs occur on both sides of the equator, but they are composed largely of Poritidæ and Milleporidæ.

On the west coast of America the minimum isotherm of 68° F. runs north of the equator, and the Galapagos Islands have no reefs, for the temperature there often falls below 68° F. Reef-building corals occur in patches from Panama to Magdalena Bay on the coast of Lower California, but they do not form any reefs, and are composed almost entirely of Poritidæ.

Fossil deposits of Astræidæ, in any age and anywhere, indicate with a reasonable degree of certainty that the sea had a temperature of not less than 74° F., and corals of any of the modern reef-building groups show that the temperature was not less than 68° F.

But the reef-building Hexacoralla are not known below the Triassic, and for the Paleozoic era we must use other criteria. From the Cambrian to the upper part of the Carboniferous coral reefs are known, but they are formed by Favositidæ and Tetracoralla, both wholly extinct, so that we can only infer their habits. It is, however, nearly certain that these ancient reef-forming corals lived under the same conditions as the modern groups, and that the temperature of the sea where they lived was tropical.

Absence of coral reefs from any formation does not prove that the temperature of that time was not tropical, for even now coral reefs are lacking in many parts of the tropics, on account of unfavorable conditions other than low temperature. Also the corals of the ancient reefs have often been obliterated by metamorphism, and only massive limestone left.

[1] J. D. Dana, "Corals and Coral Islands," 3d ed. (1890), pp. 108–114.

Now while one swallow does not make a summer, one reef-building coral, or one palm, or one cycad does, since neither one of these organisms now lives outside of a warm climate.

Paleozoic Climate of the West Coast

All the Paleozoic sediments on the west coast are marine, and while the record is fragmentary, the evidence points uniformly to warm temperature of the sea, and, thus by inference, of the land. The Lower Cambrian, or Pre-Cambrian, glaciation of China and Australia has not been recognized in this part of the world, but this is merely negative, since land formations of that period are unknown here.

The Lower Cambrian limestones of Inyo County, California, and the adjacent region of Nevada, have extensive coral reefs of Archæocyathidæ; similar reefs are known in Europe and Australia, but not in the Arctic region.

In the Silurian of Plumas County, and the Devonian of Shasta County, California, there are coral reefs composed of Favositidæ and Tetracoralla, and in both these ages similar reefs are known in Siberia and Alaska, which may show that the temperature of the sea had grown warmer in the middle Paleozoic, with a northward extension of the isotherms.

The Carboniferous of Shasta and Plumas counties, California, has great limestone masses full of reef-building Tetracoralla, and similar reefs are known up to 82° N. lat., and down to the equator. Whatever the temperature was, it was remarkably uniform. The flora of the Coal Measures[2] in the northern hemisphere indicates a warm and equable climate for the land, extending up into the Arctic region, and without evidence of any trace of climatic zones.

The Permian, or Upper Carboniferous, glaciation, which was so widespread in India, Australia, South Africa and South America, has not been recognized in North America. But this event is now recognized as the greatest catastrophe in geologic history, and its effects probably extended far beyond the limits of glaciation. With the accompanying lowering of oceanic temperature, near the end of the Paleozoic era, the ancient types of reef-building corals, the Favositidæ and Tetracoralla, disappeared. Hardly anything but solitary corals, that may have been deep-water forms, are left in the Permian, and in the Lower Triassic no corals of any sort are known.

The Hexacoralla, the modern reef-builders, had already originated in the Paleozoic, but were then little developed, unspecialized types. They escaped the general catastrophe either by being distributed in regions where the destruction did not take place, or by being then deep-

[2] David White, *Jour. Geol.*, Vol. XVII., No. 4 (1909), p. 338.

sea forms, habituated to lower temperatures. When the amelioration of the earth's climate took place, near the beginning of the Mesozoic era, they found a free field on the coasts, and at once took possession. In the epoch of the Middle Triassic they had already become widely distributed, but as yet had formed no known reefs.

The distribution of the cephalopods in time shows a strong contrast to that of the corals. There is an unbroken genetic series of ammonoids and nautiloids from the Coal Measures, through the Permian, and extending into the Lower Triassic, several genera ranging through the interval. This does not necessarily mean that the cephalopods were hardier, for they probably were not. But they were very widely distributed, and must have lived on in some region, or regions, where great catastrophe had little or no effect, and by their superior facility in locomotion got back into the regions affected by glaciation, when the temperature of the seas had risen again.

Mesozoic Climates of the West Coast

Since corals are wholly unknown in the Lower Triassic, and since the flora of that epoch is as yet little known, it is not possible to determine the temperature of either the land or the water. It is, however, certain that the oceanic temperature in India, in western America and in northern Siberia, was the same, for there is a remarkable similarity of the cephalopod faunas in all three regions.

It is also known that in the Permian and the Lower Triassic a dry climate prevailed over large areas, for products of desiccation, such as gypsum and saline deposits are common in many parts of the world, and even in regions that are now rainy, as in western Europe.

In the Upper Triassic there are great limestone masses and coral reefs in the Alps, the Himalayas and in California, with many species common to the three regions. Certainly the epoch of the *Tropites subbullatus* fauna was tropical up as far as Shasta County, California, for there reefs of Astræidæ are extensive. We may even be justified in assuming that the isotherm of 74° F. extended that far north. Also in the Blue Mountains of northeastern Oregon there are coral reefs in the Upper Triassic, but no Astræidæ were found in them, only extinct genera. This outlying occurrence may correspond to the isotherm of 68° F., in which now corals may form reefs, but Astræidæ can not flourish.

After the formation of the coral reefs in northern California and Oregon the facies changed suddenly from limestones to clay shales, and with this came an abrupt change in the marine fauna. The Indian types of cephalopods disappeared entirely, and in their stead came in a fauna of which the home seems to have been the boreal region. *Pseudomonotis ochotica* was the commonest species in this fauna, and was

widely distributed around the North Pacific. It has also been found as far south as Peru, on one side, and down to the equatorial part of the Indian Ocean on the other. This wide dispersion does not necessarily mean a lowering of the oceanic temperature during this epoch, for this species may have lived in deep water, and therefore could easily find uniform temperature from the equator to the Arctic region. But the sudden change of facies and impoverishment of the fauna over such an enormous area are suggestive. A slight drop in temperature, below 68° F. would account for it.

The last epoch of the Triassic, the Rhætic, has no marine faunas anywhere in America, but the flora, with its abundant cycads, is widely distributed in both the northern and the southern hemisphere. Coal deposits are common in this epoch, and this points to a very uniform and mild climate far beyond the present temperate zones.

At the opening of the Jurassic period we find a Mediterranean marine fauna established in western America; this same fauna also extended from the equatorial regions to Alaska, so that we are without evidence as to climatic zones, and can only infer that the temperature was uniform.

In the Middle Jurassic reef-building corals lived in the waters of the Great Basin Sea, and their remains are quite common in Plumas County, California, but in that province they formed no reefs, for the waters were not clear, and much disturbed by the deposition of volcanic ash. Abundant cycads lived on the land in California at this time, adding their testimony to the warmth of the climate. This same Middle Jurassic marine fauna extended up to Queen Charlotte Islands, and to southern Alaska, in the latter place with cycads interbedded with the salt-water fossils. Here, as was often the case, the cycads extended some distance north of the corals, a coral reef with Astræidæ being known in this epoch on Queen Charlotte Islands, in 53° N. lat., while cycads occur as far north as 57° N. lat. In this same epoch the northern limit for coral reefs in the Atlantic region was 53° N., in southern England, while the other invertebrates and cycads ranged up to 80° N. lat. A mild climate must have extended up nearly to the pole.

The Upper Jurassic of California shows a sharp contrast to the preceding epoch; its marine fauna is scanty, and what little there is belongs to the boreal type, the *Aucella* fauna, which is characteristic of Russia, northern Siberia and Alaska. For a short time this fauna ranged down into the edge of the tropics in Mexico. This does not mean that the climate was cold, but merely that the temperature was lower than that at which reef-building corals and the other sensitive invertebrates could flourish. In the Lower Cretaceous we find the same boreal type still persisting as far south as middle California. But here,

as in the Upper Jurassic, the evidence is conflicting, for cycads are known in both formations.

In the Lower Cretaceous epoch there was a sharp contrast between conditions on the Pacific and those on the Atlantic side of America. In the Atlantic waters coral reefs extended as far north as Texas, while no corals at all are known in the Pacific waters of America in California. In the Upper Cretaceous, on the other hand, coral reefs extended to Ensenada, Lower California, lat. 31° 30′ N., while in the Atlantic waters they did not reach so far north. In other words, the Pacific waters on the western side of America became warmer in Upper Cretaceous time than they were in the preceding epoch, while in the Atlantic the conditions were reversed, as was the case also in southern Europe, where coral reefs extended much further north in the Lower Cretaceous than they did in the Upper Cretaceous.

The change in faunal geography in western America about the middle of the Cretaceous period is very remarkable. The Knoxville epoch had a boreal fauna, while with the opening of the Horsetown epoch the facies changed rather abruptly, and an Indian fauna came in. Swarms of ammonites of Indian type occupied the shallow marginal sea, showing at least a great change in geographic connections, if not in climate. It has been suggested by the writer that the opening of the Bering Sea passage during the Mariposa epoch of the Upper Jurassic and the Knoxville epoch of the Lower Cretaceous would account satisfactorily for the change of facies and the lowering of the temperature at that time. The closing of this passage near the end of the Knoxville epoch explains the change of facies from the boreal to the Indian type of fauna, and also the accompanying rise of oceanic temperature on the coasts of western America.

The favorable conditions, inaugurated in the middle of the Cretaceous, continued throughout the Chico epoch, during which coral reefs extended up to Ensenada, Lower California, N. lat. 31° 30′, and a warm climate prevailed even in Alaska. Reef-building corals extended up to the middle of California, but they formed no reefs, since there were no stretches of clear sheltered waters in which they could flourish.

Neozoic Climates of the West Coast

The Eocene climate of the west coast was nearly the same as that of the Upper Cretaceous. The marine deposits have numerous molluscan genera that are now confined to the tropics, and on the land palms abounded in California, Washington and Alaska. No reef-building corals of this age are yet known anywhere on the west coast, and it is probable that the marine temperature was slightly below that necessary for their existence in this region. The climate of the coast, from California to Alaska, was probably very much like that of the

states bordering the Gulf of Mexico. There to-day many tropical molluscan genera are found in the waters, and on the marginal coastal plain there is a mixture of palms, deciduous trees and conifers. This is just what we find in the fossil Eocene flora of California and Puget Sound; laurels, figs, sycamores, chestnuts, elms, liquidambar, oaks, palms and sequoias lived together. From this association we should infer that the climate of the west coast was no longer tropical, but subtropical, and very rainy.

The middle Tertiary faunas are very like the present in the association of genera, and the flora on the land agrees with this. The palms have disappeared, but laurels still occur. It is probable that the climate of the upper Miocene had about the same temperature as that of the present in California, but it had, apparently, a much greater rainfall, or one much more evenly distributed.

The Tertiary flora of the west coast was immensely richer than the present. No elm, liquidambar, nor true laurel lives wild on the west coast now, and many other types that flourished here are gone. The impoverishment of the present tree flora of California, as compared with that of the Tertiary, has been ascribed to volcanic activity, but this is absurd. In the first place the great extinction of the old types took place in the lowering of temperature near the end of Eocene time, while the era of great lava outbursts on the west coast was after the middle of the Miocene. The climate continued to cool off in the Pliocene, as is shown by the northern types of mollusca that then ranged as far south as Los Angeles, and by the freshwater lake deposits of middle California, which contain a fauna at present confined to the Klamath region of northern California and southern Oregon. The flora of the Pliocene in California is very scanty, composed largely of willows, alders and conifers, very much like that of the Olympic Peninsula in Washington.

The constantly decreasing temperature throughout the Tertiary is sufficient to account for the reduction of the flora. The tropical and finally the warm-temperate types were killed off locally, and such as were confined to this region were wholly extinguished. Some of the forms that lived in more favored regions to the south returned after the Glacial epoch. But most of the region to the south of California is not favorable to the extensive growth of forests, and many of the types have never returned to California, except when brought in by man.

In the early Quaternary there were extensive ice-sheets in the Sierra Nevada, and probably the climate of the sea-coast was cool. The glaciers came down the slopes to a line that is now about 3,500 feet above sea-level; it is thought, however, that California stood considerably higher than now, and that conditions here were more like those of the present on the Olympic Peninsula.

After the Glacial epoch was past the climate became warmer, and many mollusca crept slowly up the coast, from the warm waters of Lower California. This southern type reached as far north as Santa Barbara in the upper San Pedro epoch of the Quaternary, during which time the sea probably had a temperature as warm as it now is on the shores of Lower California.

This warming up of the west coast was no mere local phenomenon, for the same thing occurred at the same time on the eastern coast of America, when a warm-water fauna ranged up to the Champlain district. And also in Europe the climate after the Glacial epoch was, for a little while, warmer than it is at present. After the San Pedro epoch on the west coast, and the Champlain in the east the climatic conditions became approximately what they now are, although it may well be that the Terrace epoch had a larger rainfall than that of the present.

Summary

In the foregoing pages it will be noted that during all the known Paleozoic the west coast enjoyed a warm and probably tropical climate, with some suggestion of a northward march of the isotherms, reaching a culmination in the Upper Carboniferous. There is then some indication of a southward recession of the isotherms in the Permian, and a renewed northward advance in the Lower Triassic. This continued until the middle of the Jurassic, but the farthest north was never again reached in the Pacific waters.

In the Upper Jurassic and the Lower Cretaceous another considerable southward recession of the isotherms is indicated, followed by a renewed northward advance in the middle of the Cretaceous. But this advance did not reach so far north as that of the Middle Jurassic. The Eocene epoch shows the temperature of the west coast nearly holding its own, but with a probable slight reduction. The Miocene climate had grown considerably cooler than that of the Eocene, and by the Pliocene it was already rather cold as far south as California. The early Quaternary climate was probably even colder than the Pliocene, for there we have the local ice-sheets in the high mountains of California. The post-Glacial amelioration of climate is as distinct here as it was in eastern America, and in Europe, and probably as short-lived. Middle and late Quaternary time was probably much longer than we have been accustomed to consider it, and there have doubtless been considerable fluctuations in our climate in that period, but we have as yet been unable to decipher these in the geologic record of the west coast.

SOME TESTS OF ACADEMIC EFFICIENCY[1]

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I HAVE come here from Boston for the simple purpose of manifesting the good will of an eastern institution to this vigorous university in the middle west. I need not remind you of the historical connection between Massachusetts and Kansas, but I should like to express the hope that frequent interchange of academic courtesies may at any rate keep alive the memories of that interesting connection. My mission here, however, is extremely simple and my duty entirely congenial. It is merely to congratulate you on this new exhibition of western energy and to join with you most heartily in the dedication of your splendid laboratories to the great purpose for which they were designed, the pursuit of science and its application to the problems of to-day.

I need not assure you that I have come here in no spirit of eastern superiority. In fact, if there is anything of east and west in my mind at all it is the old suggestion that the wise men of the east displayed their wisdom in going to the west for inspiration. I believe that this might well be done more frequently to-day.

But what impresses me most in a visit such as this is not so much the difference between the east and west, not so much the distinction as the points of similarity. The old distinctions seem to be rapidly disappearing and all are recognizing that the prosperity of one part of the country is intimately bound up with the prosperity of every other part. And there is no field of our national activity in which this is more clearly recognized than in the field of education. There have been differences, there have been jealousies, there have been rivalries between different colleges and technical schools. There are some of these differences and rivalries still left, but never before was there a time when the essential solidarity of the whole educational world was more clearly recognized, and when men saw so well as they do to-day that in all of our colleges, universities and technical schools we are fighting, if we are fighting at all, on the same side. Rivalries in some sense there must needs be, but no longer do we desire weak rivals. We want our rivals to be strong and we want them strong so that in the process of emulation and of competition we may be all forced to higher levels and there may be a general trend upwards rather than downwards.

[1] An address delivered at the dedication of the engineering laboratories of the University of Kansas, February 25, 1910.

Now it seems to me that in the process of striving to raise our standards we are a little apt to slavishly copy what other people are doing without clearly recognizing why we are copying them and what we are striving to attain. One college opens a new department in some sphere of activity; another thinks it is bound to do the same thing, although the local conditions may be totally different. If one school of engineering establishes a new course another is sure to follow with a similar course. We need a measuring rod to determine whether our level is above or below our competitors. How are we to reach a real standard of efficiency? How are we to know whether our institution is better or worse than some other institution? Of course various standards have been suggested. The great objection to most of them is that they are too mechanical. The best part of any educational institution is a spiritual thing and a spiritual thing must be spiritually discerned.

Now one of the institutions in this country which is doing its best to carry out a leveling process and trying to raise the institutions of the country is the Carnegie Foundation for the Advancement of Teaching. Its course is so brief that none here can have missed the opportunity of following it. Founded only a few years ago by Mr. Carnegie for the avowed purpose of pensioning professors who had long served their country as teachers and investigators, it is being put by those who have managed it to a quite different purpose and that purpose is to standardize our institutions.

I am not going to discuss what the foundation has done or is doing, but I should like to refer to a report, the advance sheets of which the Carnegie Foundation has just issued, under the title "A Comparison of Academic and Business Efficiency." The fundamental idea that suggested the drawing up of the report is one that must attract us all. It was to obtain a report on the efficiency of different educational institutions looked at from the view-point of a business man. To this end the foundation employed the services of an accomplished engineer, Mr. Cooke, and asked him to report on a number of educational institutions in this country. He was instructed to employ the same methods in his investigation that he would if he were reporting on the efficiency of a cotton mill or an automobile factory. To simplify the problem he was to confine his attention to eight institutions; to further simplify it he was to deal with a single department in each of these instituions; that department happened to be the department of physics. The report is a lengthy one—those of you who are interested will doubtless read it for yourselves—but I may just sketch with extreme brevity the fundamental guiding principle.

Mr. Cooke begins with the truism that if you are to test the efficiency of a factory from a business point of view you want to know the cost of the working of the machinery. He therefore proceeds to

discuss how much it costs to train men in physics in these different institutions and sets up a standard of measurement of what he calls the "student hour," the cost of teaching a student the subject of physics for a single hour. After an elaborate system of figures and a great deal of computation he discovers what is supposed to be the cost of teaching a student in physics for one hour in Harvard and Boston Tech, and these different institutions. Now whether his figures really represent the cost or not is questionable, but there can be no doubt that they do not gauge the efficiency of the institutions under consideration.

The efficiency of an automobile is not gauged by its cost, and certainly the efficiency of Harvard or Boston Tech is not gauged by their cost. You must of course look to the product. Now a man of Mr. Cooke's acumen could not overlook so obvious a fact, although he passes it over with almost unpardonable brevity in a report that professes to deal with the question of *efficiency*. He does not always seem quite true to himself. He tells us in one place that "the cost per student-hour has absolutely no value in distinguishing relative educational values." Elsewhere he says "certainly some idea of quality will be gained by simply knowing the cost." However, he does recognize that the *quality* of the product must be tested before we have any real gauge of efficiency, but when it comes to suggestions for a test of quality he formulates a plan that a serious educator could regard only with laughter or with tears. Here it is—let us establish a central bureau to which may be submitted the examination papers and the answers from the five highest and five lowest students, and let the central authority assign marks for the difficulty of the questions and the rigor with which they were answered. I shall not presume upon your patience by pointing out to what abuses such a plan would be exposed, nor how paltry a contribution it is towards the solution of an extremely important national problem. I should like, however, to call your attention to various matters to be kept in view when we set out on the task of testing the efficiency of any educational institution.

I would remark at the outset that the matter is extremely complex and that no wise man would even dream of giving a *numerical* measure of the efficiency of Harvard or the University of Kansas. He would no more do that than he would say that the efficiency of his friend Jones is 62, and of Smith is 55. On the face of it, such apparent accuracy is ridiculous. But we do want to know in a general way how we are to gauge efficiency, and I need only sketch the process which is a fairly obvious one. The natural way of attacking the problem would be to attack it directly. We are interested not in the machinery but in the product. The obvious procedure would be to examine the product in the different institutions and see how they stand relatively to one another. We would have, of course, to set out with some funda-

mental conception of what all of these educational institutions are striving for. Unless we agreed about that we could not possibly agree as to their efficiency. Fortunately, there is general agreement to-day that the aim of all educational institutions is a social one. The University of Kansas, and Boston Tech and Columbia University and all the rest are striving to this great end—to train men to serve the state intelligently, honestly and effectively. We are all attempting that. To what extent do we succeed relatively to one another?

Now, the natural process, I say, would be to examine the product of these different institutions and see whether men coming from these different institutions have "made good." This, however, is no easy matter where there are thousands of men to be considered and the gauging of the social efficiency of a single man is so difficult and delicate an operation. And then, you have to remember that the "making good" by an individual may have really little to do with the educational institution in which he has been trained. I had the honor of being brought up in the English university of Cambridge, which has been spoken of by a poet as a "nest of singing birds," for the reason that that university has produced, if I may use the term, an extraordinarily large number of great poets. But no one seriously suggests that the poetic power of Tennyson or Wordsworth had much to do with his training in the University of Cambridge. And so it is with the actual making good of a great many of our leading men; in most cases it is only indirectly due to the training they received in the university. Then you must bear in mind that an extremely important factor in the making of good flour is to have good grain, and that one institution might be as efficient as another, but yet for the lack of good grain not turn out so fine a product. Thus you would have to gauge not only the graduate, but the men at entrance, and this would greatly complicate the problem. Practically, then, I think, you would have to proceed indirectly by carefully examining the means that were employed in the institution to produce the results. If you bore in mind the idea of social service as a thing toward which we are all striving, you would have to begin, I suppose, with some estimate of the relative social value of a college education and the education in a professional school, taking each at its best. The aim of a college is to train a man broadly and so develop every side of his charcter that he can devote himself to the duties of citizenship in whatever special sphere of activity he can be most effective. The professional school does not neglect breadth of outlook or the duties of citizenship, but it bends its powers to the education of men for the service of society through the medium of definite professions. To gauge the relative value of these two schools you would need to decide whether it was more important to have an alert broad-minded man with no professional skill, or a man who could

set your leg if you broke it, or bridge the Mississippi if you wanted to cross it. It would be an extremely difficult question to decide, but you would have to do it somehow if you wanted to solve this problem numerically. Then if you confined your attention to professional schools you would need to estimate the relative value to the community of a doctor, lawyer, clergyman or engineer, and so on. In doing this you would necessarily take into account local needs and local peculiarities. You would have to consider, as a single sample of what I mean, whether there was a real demand in the community for an increased number of doctors, and so with the other professions.

Here to-day we are celebrating the foundation of buildings which are to be devoted to science and its applications, and so it would seem natural to consider that kind of educational effort somewhat more minutely. You would have to begin with deciding on the usefulness to the community of an education such as is being given in this institution, and in particular in this school of engineering where men are trained in the sciences for the service of the state. Now, it is such a commonplace to-day that science has revolutionized the world that I shall not weary you with attempting to demonstrate that fact. At the same time I should like to say in passing that, like many another commonplace, it is too often neglected in actual practise. It seems that individuals and states in making provisions for education constantly fail to recognize how enormously important to the welfare of the state it is that men should be trained in science, and in its application to every branch of practical life. We live in an age preeminently scientific, and if we are not able to cope with a problem scientifically we can not cope with it at all. But not only is a scientific training essential anywhere to any country to-day, it is, I think, peculiarly important in this country at this particular time. It seems to me that one of the great dangers of our democracy is the prevalence of the idea that one man is as good as another. It is an idea founded on an erroneous theory of democracy and one that appears utterly false from a scientific point of view. It too often gives support to the doctrine that any man will do for any position that he is clever enough to get. Nothing has surprised me more in moving about this country than to see countless instances of men who have had no adequate scientific training employed in the service of cities and of states, to do work that really needs a very considerable scientific equipment. They are amateurs doing the work of professionals. We have suffered too much at the hands of these amateurs, and we must remove them—root and branch. We must educate our communities in such a way that it will shock their moral sense to see a man, let us say, administering a department of public health who knows little or nothing of biology and bacteriology or any of the other fundamental sciences that enter into the very heart of his

work. Then we have to bear in mind that this nation is peculiarly given to extravagance. This is due largely to the optimism of the American people, a quality on which so much of America's success depends. But it has its drawbacks, like other good things, and the spirit of extravagance may yet drive us upon the rocks. We must not forget that conditions are rapidly changing and that what might suffice for a past generation will not do to-day. A generation ago we could speak of our natural resources as practically unlimited, now we begin to see their end—at least in some directions. And apart from this we must recognize that under any circumstances *waste* is a sin and that the record of progress is largely the record of the elimination of waste. We shall have to make up for the diminution of our natural resources by new applications of science which will make ten blades of grass grow where one grew before, and by new inventions which will save fifty per cent. or more of the waste in most of our industrial processes. However, even without any new inventions we could easily make enormous savings by the proper use of existing knowledge. Let me give you a single example. A few years ago a graduate of the Massachusetts Institute of Technology, trained in the department of biology, was appointed to an administrative post in one of the great cities. He invented nothing new, but merely joined common sense and executive ability to the scientific knowledge that his training at "Tech" had given him. Before long he had given the city a much better service than it had ever had before, and at the same time had *saved it more than a million dollars each year.* Suppose you multiply the million dollars thus saved by even a very small fraction of the thousands of men trained each year in the scientific institutions of this country and you may form some estimate of the saving grace of such institutions and of their value to the community.

I think, then, that there can be no question that you would have to put in a very large factor of usefulness, if you were estimating the value of such an educational institution as we are considering to-day—at least if you realize in any adequate degree the importance of scientific knowledge in public and private life. And, of course, a not unimportant element in such scientific knowledge would be a knowledge of physics, and under ideal circumstances this knowlege might be at least partially tested by Mr. Cooke's method, to which reference has already been made. It would, however, at best be only a partial test of knowledge, and it would neglect a great many factors of the first importance. May I remind you that *knowledge* is very far from being everything and that much of our educational work to-day and in the future must be to deliberately *smash up the idol of knowledge.* We are peculiarly prone to this form of idolatry in a scientific school, for science rightly lays a great stress on facts and their accurate apprehension. We are

very apt to overestimate the value of such knowledge, and it is because we have done this so much in the past that there has been so much disappointment in many quarters over the results of scientific teaching. It is a fact that water is composed of oxygen and hydrogen, and it is the knowledge of such facts that is tested by such examinations as Mr. Cooke proposes. But, except to a very few, such knowledge profits little or nothing—what is infinitely more valuable is an understanding of the method by which the facts are reached and an appreciation of the spirit that compels their investigation. Here, as elsewhere, it is the spirit that giveth life, and any test of efficiency that ignores the spirit and deals only with the bare fact is a mockery.

It would be a monstrous oversight to ignore the method and the spirit of the teaching. Are the pupils trained by a mere grind over knowledge, a mere hammering in of facts—enough perhaps to ensure that they reach the requisite 50 or 60 per cent. in Mr. Cooke's examination? We must all know schools that would appear to be highly efficient from such a test, and which are really extremely inefficient; and on the other hand some of our best institutions might not make a very good show when subjected to Mr. Cooke's scrutiny. At the Boston Tech a method has been in vogue for long that is there deemed highly satisfactory—it is known as the "do-it-yourself method." The students are put as much as possible upon their own resources and learning is not made easy where it seems better for a man to experience the apparent hardship of overcoming a difficulty for himself.

Then, when considering method, we should want to know whether the students are taught to master fundamental principles, or to spend most of their time over details or particular examples. Is it made manifest to them that the details of practise are constantly changing, that what is good in that respect to-day may be antiquated to-morrow, whereas fundamental principles, like the brook, go on forever?

As to the spirit of the teaching—is it possible to overlook the character of the teachers? Are they men who understand the depth and breadth of their calling? Do they take a large view of the life of to-day, and have some prevision of to-morrow? Are their circumstances such as to make this larger outlook possible or probable? Are they narrow specialists or broad-minded, far-seeing men? Are they paid so that a reasonably full life is a possibility, or are they so ground down by poverty that they must give most of their thought to the vexed question of the cost of living?

Finally, is a successful effort made by the teachers to convey their largeness of view and breadth of outlook to their pupils? Do the students learn to understand that science does not affect mankind merely on the material side? Do they see that all the changes that science has brought about necessarily involve a profound mental and

spiritual change—a change, so great, indeed, that it is well-nigh impossible for us thoroughly to sympathize with our grandfathers? Do they realize that science has thrust us into a new world and that our new surroundings have made us new men? Unless they appreciate this they can not be in real communion with the life of this age. They must live more or less apart, and move away from the great current that is sweeping the world along. Like Bernard Shaw, they must find that they were born in the seventeenth century and that they have not yet outlived it.

I might express this last test of efficiency otherwise by saying that you must look to the *cultural* element in the teaching of science—but I am afraid of the word "culture." It has been so terribly abused. Some speak as if the test of culture were the knowledge of Latin, or of Greek, or of French literature, or of Italian painting, or of what not. As a matter of fact it is none of these things, for I take it that the root of culture in any worthy sense of that word is *the possession of an ideal that is broad enough to form the basis of a sane criticism of life*. I hope that I need not turn aside to demonstrate the competency of science to present such an ideal. I willingly admit that some such ideal may be reached by various paths, through the study of literature, or of art, or of science. I should be the last to suggest that these are rival or mutually exclusive pursuits or that any one can justly claim a monopoly of culture. To know the best that has been said in literature and to use this as a touchstone in the criticism of the life of to-day, or to reach through art the ideal of perfection in form and color and make this broad enough to embrace life as a whole—each opens a promising avenue to culture. But how can a criticism of life be broadly enough based to-day unless the main results of scientific investigation lie at its roots and the method and the spirit of science be in the atmosphere that surrounds it? It can not, I think, be broad enough, unless we greatly exaggerate the part that science has played and is playing in the modern world. And I do not think that we exaggerate it, for practically all must recognize that there are few important problems of life to-day that science does not touch and touch most closely. This being the case, can a school be declared efficient that fails to give its students a vision and a grasp of the scientific ideal—an ideal that will guide them in the solution of all the complex problems that face individuals and face the state?

THE PROPHECY OF FRANCIS BACON (1560–1910)

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I. *Bacon and the Spirit of Discovery.*—There are several ways in which the importance of a philosopher may be estimated. He may be regarded as an exponent of his times; that is, as a representation in which the manifold tendencies of an age are focalized and idealized. Or he may be regarded as the author of a panorama of existence, of a world-view or system, which, while it may be superseded, will always retain enough of logical and imaginative coherence to make it typical and classic. Or the philosopher, like other servants of mankind, may be judged according to the degree in which he has been confirmed by posterity. Judged by this last standard, the great philosopher will be the philosopher who, while he may, like Bacon, have been born three hundred and fifty years ago, is nevertheless modern, in the sense that he is identified with important ideas which are now generally held to be true. This brief summary aims to present the Bacon that is living to-day in our common opinion, in our expert knowledge, and in our dominant ideals.

Any one who considers Bacon in relation to European civilization of the modern period must be impressed with the degree to which he represents its progressive ideas. Those characteristics of the sixteenth and seventeenth centuries which are most marked in Bacon are the characteristics in which they anticipate later centuries. It is possible for our immediate purposes to reduce these characteristics to one: the disposition, namely, to look for a betterment of human life from the advancement of knowledge. "Advancement of knowledge" does not here mean the education of the individual, but the winning of new truths by the race and for the good of the race. We may call this the spirit of discovery, where "discovery" is used both in the theoretical and in the practical sense. Bacon himself was not a discoverer of new scientific truths, but the discoverer of the art of discovery. As he expressed it, he "rang the bell that called the other wits together." While it is doubtless inaccurate to attribute so general an idea to any individual authorship, Bacon was its greatest prophet. His brilliant literary gifts, his imagination, his sanguine temperament, his breadth of view and his native regard for utility, the very qualities that helped to unfit him for exact research, made him the most important medium through which the idea of discovery, or of intellectual conquest, has gradually become the hope of mankind.

II. *The Baconian Reform.*—This idea was defined by Bacon largely in opposition to what he believed to be the blindness and errors of his own and earlier times. Philosophical literature nowhere else contains so acute and so comprehensive an examination of man's intellectual bad habits. Bacon's criticisms may conveniently be brought together under four heads.

First, he defined the persistent error of *anthropomorphism.* It is customary for man to fashion things after himself. He is deceived by what Bacon calls the "idols of the tribe" or the prejudices characteristic of human nature in general, and by the "idols of the den" or the prejudices peculiar to the individual. But if he is to view nature as it is, he must efface himself.

Second, he found the thought of his own time to suffer peculiarly from *conventionality.* It was customary for men to accept what was current and supported by general opinion. There are two important means through which arbitrary or ungrounded ideas are foisted upon belief: language, which gives rise to what Bacon calls the "idols of the market-place," and established systems, or theories which have the stage, and which give rise to what Bacon calls the "idols of the theatre." In the interests of truth it is necessary to guard against the suggestive power of words, which are often obscure or even meaningless, and against the inertia of doctrines that have acquired repute and prestige.

Third, it was customary in Bacon's time, to a degree that is scarcely intelligible to-day, to assent to theories of nature on grounds of *authority,* ecclesiastical or political. Bacon is among the first to formulate the principle of tolerance, according to which there is hope of knowledge, provided only that the mind be free from external constraint. The truth-seeking mind can acknowledge no obligations except to evidence.

Fourth, Bacon attacked the tendency, common at the time of the Renaissance, to rely on *antiquity.* The essentially modern character of Bacon's mind is nowhere more apparent than in his repudiation of the idea that dominated the revival of letters. He detected the dangerous fallacy which had arisen with the new study of the ancient languages and literatures. Historical retrospect inverts the intellectual values of the race. The wisdom of the ancients is but the folly of youth—*Antiquitas sæculi juventus mundi.* The hope of knowledge lies not in a return to childhood, but in a maturity yet to come.

III. *The Baconian Survey.*—As a pioneer in a new intellectual enterprise, it fell to Bacon to draw a rude map of the settled domain and border wilderness of knowledge. It is impossible here to enter into the merits and demerits of his classification of the sciences. Most interesting to us of the present is his explicit provision for what is

now known as "applied science." But there can be no doubt of the service which Bacon rendered in making such a classification at all. To Bacon modern science is largely indebted for the sense of solidarity that obtains among all special investigators. He was, in a measure at least, responsible for the organization of the Royal Society in London, and of similar societies on the continent. He inspired the collective scientific movement of the Encyclopædists; and, directly or indirectly, the systematization of science made by Comte, Spencer and others. The present idea, then, that the several sciences are the members of one body, and that those who serve them are serving in one army to achieve the conquest of the unknown, is an idea to which Bacon testified clearly and effectually.

IV. *The Baconian Method.*—But Bacon did not merely point out the promised land and exhort men to discovery; he organized a plan of campaign. There is an opinion to the effect that while Bacon was enlightened in his general ideas, he was benighted in his particular ideas. This opinion is entirely unjust. Bacon does make many of the mistakes current in his time; and he deliberately makes many loose statements in the hope that they may prove suggestive and stimulating. Furthermore, he necessarily uses terms, such as "form," which, because they were borrowed from Greek and medieval thought, suggest to our minds something pre-scientific and obsolete. But this very term, as actually employed by Bacon, is the closest approximation in his time to the modern conception of cause, as employed in such sciences as molecular physics and chemistry. Furthermore, and be it said to his great and enduring credit, he was the great systematizer and popularizer of experimental method. The incompleteness of the Baconian method is the incompleteness of the experimental method. Although he did not by any means ignore it, it is true that Bacon did not adequately realize the importance of the quantitative or mathematical formulation of scientific laws. But this fact in no wise affects the correctness of his statement of the experimental method. The Baconian plan of research, avoiding technicalities, may be said to contain four important ideas, all of which have been approved and employed in subsequent scientific procedure.

His first and fundamental idea is that of *observation.* Bacon never wearies of reminding us that the mind must be brought into direct contact with things. In the study of nature, we may see, he believes, by the "ray direct." To avoid verbalism, dogmatism or ambiguity, it is necessary that the mind should be open to the facts, and that it should follow their leading. "We can only conquer nature by first obeying her." But Bacon understood the fruitlessness of desultory observation. For purposes of explanation all facts are not equally significant.

Hence, secondly, he was led to define certain methods or *canons of induction.* It was Bacon who first called attention to the importance of "glaring" or "striking" instances, in which the phenomenon under investigation is thrown into relief; "parallel" instances, which permit of the argument from analogy; and "crucial" instances, which serve as tests of contrary hypotheses. From Bacon, Mill derived the methods to which he gave such prominence in his *Logic,* the methods, namely, of "agreement," "difference" and "concomitant variation." By means of these methods it is possible to single out from among the circumstances attending or preceding the phenomenon to be explained, that which is its probable cause. That which is present when the phenomenon is present, which is absent when the phenomenon is absent, and which shows like quantitative changes, may be assumed to be connected with the phenomenon, and to point the way to its explanation.

But, thirdly, it is necessary to supplement observation of the natural course of events with artificial *experiments.* Nature, like men, will reveal her secrets only when put to the torture. Bacon was a consistent advocate of the first-hand manipulation of natural bodies. He saw this to be the only method of study which afforded any prospect of laying bare the more "subtle" physical phenomena, such as heat, light and the transmutation of substances. The later development of physics and chemistry not only confirmed this judgment, but in several signal cases fulfilled definite predictions which Bacon based on it.

Fourthly, Bacon recommended the *comparative* and *historical* method. He was one of the first to appreciate the importance of studying all phenomena that develop, in different stages of their development. In the particular case of anatomy, he called attention to the importance of studying the structure of organs in their simpler forms, and using the results as a key to the complex forms.

V. *The Baconian Pragmatism.*—Bacon's extraordinary modernism appears not only in his definition of sound and fruitful methods of scientific study, but also in his conception of the relation of science to civilization. And in nothing is he so modern as in this. He asserted that the hope of man lay in his advancing knowledge and control of nature. This idea is undoubtedly a present commonplace, but there are few philosophers that anticipate the commonplaces of mankind by three centuries and a half! But the idea is too fundamental properly to be called a commonplace. It is the most fruitful idea in modern life, the main presupposition of progress. Bacon sought to promote learning for the sake of power. That this is essentially a modern idea will be apparent to any one who will study the motives underlying earlier periods of European civilization. The ancient world had its critical and its dogmatic idea of progress. The

former was that of national or racial aggrandizement, the conquest of territory and political control. The latter, contributed by the genius of Greece, was the humanistic idea of the intensive cultivation and refinement of human nature. These ancient ideas were superseded by Christian supernaturalism, which referred man's hope of salvation to another world which might be won by the repudiation of this. As christian Europe became secularized there developed the theocratic idea of a fixed system in which all human activities should be limited and controlled by religious authority. Finally, as a reaction against the established order, there appeared the idea of the Renaissance, an enthusiasm for antiquity, and desire to reverse the course of history. The modern idea, though it borrows something from all of these ideas, is fundamentally different. It bespeaks a solidarity of mankind in the enterprise of life, and in this manifests its christianity; and it derives from paganism a respect for human capacities, and a confidence in man's power to win the good for himself. But these motives are so united in the modern spirit as to produce something genuinely new. The good is to be won by the race and for the race; it lies in the future, and can result only from prolonged and collective endeavor; and the power to achieve it lies in the progressive knowledge and control of nature. This is the Baconian idea. The incentive to knowledge lies in its application to life. "For fruits and inventions are, as it were, sponsors and sureties for the truth of philosophies." Therefore, Bacon would have men of learning begin and end their study with the facts of their present environment. "For our road does not lie on a level, but ascends and descends, first ascending to axioms, then descending to works." In the last part of the *New Atlantis* there is a remarkable description of the riches of Solomon's House, the great museum and laboratory, the treasure house and workshop, which was "the lantern of this kingdom." The words with which the father of Solomon's House receives his visitors are a terse and eloquent summary of that which Francis Bacon prophesied, and which posterity has steadily achieved. "The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible."

JOHN DALTON AND HIS ACHIEVEMENT: A GLIMPSE ACROSS A CENTURY[1]

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IT is a melancholy reflection that the treasure laid up by great men in our memories should be corrupted often by the moth and rust of error. But, after all, this mischance roots in the nature of the case. Necessarily, our views of the past are synoptic, because the daily details, even of big events, escape us, much more the complex, ceaseless pulsations of the persons who have served their time and place rarely. Be we appreciative or critical, we lie under sore temptation to forget the inevitable limitations of human lot, and thus to lose perspective. Accordingly, my scientific colleagues,[2] with whom you have done me the honor to associate me in our effort to pay worthy homage to the genius of John Dalton (1766–1844), whose "A New System of Chemical Philosophy," although not completed in the second part of 1810,[3] had reached all its epochmaking significance, have requested me to introduce the subject with some account of the difficulties, amazing to us in our conditions, under which this strenuous pioneer labored. To this end, we must try to pierce the cultural inwardness of English life at the close of the eighteenth century, keeping in mind the peculiar qualities that characterize English science even yet.

I

As usual, the bare facts of Dalton's story need interpretation, the invisible atmosphere, their setting, imports much. Born 1766, in a little village of Cumberland, a county still remarkable for its sparse population, of a Quaker family, who eked out a precarious livelihood upon the home industry of woolen-weaving, Dalton's social relations isolated him from the chief cultural organs of the national life. Till the tender age of twelve he received such instruction as the local Friends' school afforded, and he appears to have made excellent use of his opportunities: then he went to work as a teacher there, and as a

[1] Read before the Research Club of the University of Michigan at its annual memorial meeting, devoted in 1810 to a celebration of the centennial of Dalton's atomic theory.

[2] Professor S. Lawrence Bigelow, of the department of chemistry, and Professor Karl E. Guthe, of the department of physics.

[3] It was never completed; the second part of the second volume did not appear.

hand in the paternal fields, for three years. At fifteen he migrated—literally walked!—to Kendal, forty-five miles away, where he taught in a mixed school, the venture of a cousin; and, remember, a mixed, local school in the England of that generation portends not a little respecting absence of amenity, appliances and opportunity. Here he spent twelve years, fruitful in many respects. For, the day's darg done, he contrived to improve himself by private study of Latin, Greek, French, mathematics, and "natural philosophy," with most important help and encouragement from John Gough[4] (1757–1825), the blind naturalist, celebrated by Wordsworth in "The Excursion."

> Methinks I see him how his eyeballs roll'd
> Beneath his ample brow, in darkness pained
> But each instinct with spirit, and the frame
> Of the whole countenance alive with thought,
> Fancy, and understanding; whilst the voice
> Discoursed of natural or moral truth,
> With eloquence and such authentic power,
> That in his presence humbler knowledge stood
> Abashed, and tender pity overawed.

In 1793 he removed to Manchester where, on Gough's recommendation, he had been appointed science tutor in New College, a Presbyterian institution, and, therefore, once more without the pale of national higher education; he held this position for six years, at a salary of $400. On the transference of the college to York, he resigned, and gave himself to private tuition, an exiguous vocation, sufficient for daily bread. But the Manchester experience proved a turning point, for it offered an environment wherein he could make pure science his avocation. From 1786 Dalton had been engaged in meteorological observations, and published his maiden work in the autumn of 1793—"Meteorological Observations and Essays." Printed for the author, it failed of due publicity. Thanks to his connection with the Manchester Literary and Philosophical Society, he read his famous paper, "Extraordinary Facts Relating to the Vision of Colours," in October, 1794, a month after his election. In 1801 he presented his first classical research, "On the Constitution of Mixed Gases," which was followed by three memorable papers, "On the Force of Steam or Vapor from Water and other Liquids in Different Temperatures, both in a Toricellian Vacuum and in Air," "On Evaporation" and "On the Expansion of Gases by Heat." In the last he enunciated the law of expansion of gases formulated by Gay-Lussac a few months later.

It was in 1802, after six years of research in chemistry, that he referred to the possibility of multiple proportionate combinations of the elements, in a paper entitled "On the Proportion of the Several Gases or Elastic Fluids Constituting the Atmosphere." The atomic symbols

[4] See "Dictionary of National Biography," sub voce.

devised by him are first found in his note-book under the date September 6, 1803; and, under the same date there is a table of atomic weights, showing that, by this time, he had grappled with the fundamental problem—that of fixed "relative weights of the ultimate particles of bodies." For unknown reasons Dalton appended it, in a somewhat different form, to a paper "On the Absorption of Gases by Water," read before the Manchester Society in October, 1803, but not published till November, 1805. The table was added during the interval between presentation and publication. The summer of 1804, as Dalton himself tells us, was the crucial period of the investigation. The first part of the first volume of the "New System of Chemical Philosophy," published in 1808, gives the mature theory, while the second part of 1810 describes the chemical elements in detail. Dalton was now forty-four. And it is significant that, although he had lectured twice at the London Royal Institution, and in Glasgow and Edinburgh as well, the French Academy of Science recognized his merits six years[5] before any native body. In 1822, Dalton being fifty-six, the Royal Society honored itself by his election. Another decade elapsed ere Oxford conferred her D.C.L., on the occasion of the second meeting of the British Association, and he was sixty-eight when Edinburgh enrolled him among her honorary doctors. In 1833, the government took note of his services, and he received a civil list pension, increased afterwards in 1836, when the announcement was publicly made under dramatic circumstances by Sedgwick, at the Cambridge meeting of the British Association. "The imagination may picture, if it can," writes Roscoe, "the feelings of the son of the poor Eaglesfield handloom weaver as he sat in the Senate House of the University of Cambridge listening to this eulogium—the observed of all observers."[6] As Sedgwick remarked in his striking speech, "without any powerful apparatus for making philosophical experiments—with an apparatus, indeed, many of them might think almost contemptible—and with very limited external means for employing his great natural powers, he had gone straight forward in his distinguished course, and obtained for himself, in those branches of knowledge which he had cultivated, a name not perhaps equaled by that of any other living philosopher of the world."[7] Evidently, then, Dalton wrought under grave disadvantages. What were they?

We would all agree, I take it, that certain results of human activity must remain intimately personal, and that, as a consequence, they must vary from age to age, or diverge even among different peoples in the same epoch. Art and poetry, religion and, possibly, some portions of philosophy, can not well escape these very subtle contrasts. But, with

[5] Cf. "John Dalton and the Rise of Modern Chemistry," Sir Henry E. Roscoe, p. 175.

[6] *Ibid.*, pp. 204, 205.

[7] *Ibid.*, p. 203.

Wissenschaft, particularly in that development of it known to us as positive science, the case stands far otherwise. Yet, even here, the unification of knowledge, each nation contributing its quota to the common fund, happens to be perhaps *the* achievement of the nineteenth century. Organization by countries, especially in the case of France, there was between the Renascence and the French Revolution; but a world-wide pact, embracing all effort, no matter where, did not eventuate then. Now, it is of prime moment for the present subject that the instruments of this recent unification have been the German university system, and the academies and institutes of France. By contrast, the English-speaking world possessed no such developed organs, if we except the Scottish universities where, naturally enough, Dalton met immediate recognition. Thus English science till but yesterday—*teste* even Darwin—has betrayed individualistic tendencies. These were never more evident than in Dalton's career, and during his life, moreover.

At the beginning of the nineteenth century, when Cuvier, in his "Rapport" of 1808, is extolling—and justly—the preeminence of France in the exact sciences, an extraordinary contrast manifests itself across the Channel. In the same year, John Playfair bewails the "incontrovertible proofs of the inferiority of the English mathematicians," and refers to "the public institutions of England" as its cause.[8] Eight years later, in a damnatory notice of Dealtry's "Principles of Fluxions," another writer notes it for a paradox that, Newton dead, his country "should, for the last seventy or eighty years, have been inferior to so many of its neighbours."[9] Once more, in the same review for 1822, a third critic deplores the state of affairs at Cambridge, where "for want of facilities" men "are apt to lose the spirit of investigation." Brewster's article in the *Quarterly Review*[10] which, as is well known, led to the foundation of the British Association, is no less sarcastic and outspoken. These attacks were directed against the English universities:[11] that of Babbage, the peg on which Brewster hung his exordium, had the Royal Society for its mark.[12] Now the extraordi-

[8] Cf. *Edinburgh Review,* No. XXII., January, 1808, pp. 249 f. A review of La Place's "Traité de Mécanique Céleste."

[9] *Ibid.,* No. LIII., September, 1816, pp. 87 f. (Dealtry was a fellow of Trinity College, Cambridge, and a fellow of the Royal Society.) Dalton himself made the same complaint in his lectures at the London Royal Institution (1810); cf. "A New View of the Origin of Dalton's Atomic Theory," Roscoe and Harden, p. 105.

[10] Vol. XLIII. (1830), pp. 305 f.

[11] Analogous circumstances produce analogous protests even now—*e. g.,* "Oxford at the Cross Roads," Professor Percy Gardner (1905).

[12] "Reflections on the Decline of Science in England, and on some of its Causes," by Charles Babbage, Lucasian professor of mathematics in the University of Cambridge (1830).

nary thing is that, prior to and during these years, or, to be quite exact, between 1774 and 1828, Britain had contributed at least a dozen discoveries of the first magnitude, and as many more of scarcely less importance. As you all know for what each stands, I need only mention Priestley, Black, Landen, Davy, Benjamin Thompson, Cavendish, Herschel, Nicholson and Carlisle, Dalton, Young, Wollaston, Ivory, Robert Brown, Charles Bell, Brewster, William Smith, Prout, Faraday, George Green and Rowan Hamilton. Still more wonderful, continental leaders were well aware of these contributions, and wont to emphasize them. In 1821, Cuvier gave most generous testimony: and Moll, of Utrecht, repelled Babbage's criticisms with no uncertain sound, remarking, "all must allow that it is an extraordinary circumstance for English character to be attacked by natives and defended by foreigners."

Although I can not comment upon the ramifications to-night, the puzzle has some obvious causes. The English universities were not scientific organs, but groups of residential colleges. The advancement of science was no *primary* part of their purpose, precisely as the laborious elevation of incompetents to a bare level of possible passability was no *primary* part of the purpose of the German universities or the French institutes. The colleges cherished their individuality fondly, because they aimed to produce a certain type of man for life—to anneal him by forming his *ethos,* and to fit him for the exercise of civic influence by giving him a respectable general acquaintance with the "things of the mind." In a word, the English universities did not exist to promote science or learning, any more than the continental organizations existed to provide an educational top-dressing for the sons and daughters of "the people." So, too, of pure thought. The apostolic succession of English philosophers—Bacon, Hobbes, Locke, Berkeley, Hume, the Mills, Spencer, even our contemporaries, Hodgson, Balfour, Shand, Haldane and Bertrand Russell—do not adorn the universities. Again, the peculiar position of the metropolis, its new university in the melting-pot at this moment, must be taken into account. Lacking the academic center, its scientific societies could not be organized for the advancement of discovery after the style of French and German associations.[13] These causes, together with the distinctive arrangement of English society a century ago, tended to render the great scientific pioneers lonely figures, sitting loose to the main expressions and modes of national culture. The wails over the condition of English science are traceable as much to this severance, with its absence of constant intercourse and cooperation, as to aught else. How Priestley and Dalton and Joule, Young and Davy and Faraday were hampered by these

[13] For example, in the preface to "A New System," Dalton makes the (to us) astounding statement, that he did not know whether the abstracts of his lectures, left by him for this express purpose, had been published in the *Journals* of the Royal Institution. Some five years had elapsed since their delivery!

circumstances is notorious. Others, like George Green, received no recognition whatsoever. In addition, the English passion for independence played its part. The demand for complete freedom, if it fostered the eccentricity of which the docile, drilled Germans complained, although it led to pig-headedness, as in Dalton's case, also proved greatly favorable to original genius. For, it is well to recall that more original notions, basal to modern science, have come from England than from any other land, even if, as with Newton and Darwin, France was to systematize *Newtonianisme,* Germany *Darwinismus.* England possessed no trained regiments to accomplish these things. Accordingly, if we remember all this, some apparent mysteries that cloak Dalton's career and mental characteristics begin to dissipate. In short, the Dalton we commemorate would have been nigh inconceivable had he been "born to the intellectual purple of the ancient universities"; but the Dalton we regret, who remained obdurate to Gay-Lussac despite Berzelius's intercession, might never have been. The qualities of the man, like his defects, pertained to his strong, wayward and undisciplined, if narrow and often uncouth, provincialism. *Qui a nuce nucleum esse vult, frangat nucem.*

II

Dalton maintained silence from 1793 till 1799, hindered, perhaps, by college duties. On reappearance, he soon dropped the rôle of meteorologist for that of chemist and physicist. The new line was taken in the paper entitled "Experiments and Observations on the Power of Fluids to Conduct Heat, with Reference to Count Rumford's Seventh Essay on the same Subject," read before the Manchester Society on April 12, 1799. The simple nature of his apparatus may be illustrated aptly from this communication.

> Took an ale glass of a conical figure, 2½ inches in diameter, and 3 inches deep; filled it with water that had been standing in the room, and consequently of the temperature of the air nearly. Put the bulb of a thermometer in the bottom of the glass, the scale being out of the water; then having marked the temperature, I put the red-hot tip of a poker half an inch deep in the water, holding it there steadily for half a minute; and as soon as it was withdrawn, I dipped the bulb of a sensitive thermometer about ¼ inch, when it rose in a few seconds to 180°.[14]

Then follow the tabulated temperature results. Another experiment, described in the same paper, suffices to show that Dalton had pondered the discontinuity of matter thus early. Having mixed hot and cold water for half a minute, he proceeded to determine whether the upper layer became warmer than the lower. Observing that it did not, he remarked: "If the particles of water during the agitation had not

[14] *Memoirs of the Literary and Philosophical Society of Manchester,* Vol. V., p. 381.

actually communicated their heat, the hot ones ought to have risen to the top, and the cold ones subsided, so as to have made a material difference in the temperature."[15] Furthermore, these and many other experiments afford us indications of his mental habit as a scientific investigator. Conceptual processes find him at his best; his theoretical expectations and deductions are good. In experiment he is not so happy, and what we understand by "fine" or refined work occurs seldom. Thus, in the case just cited, Dalton infers "that the expansion of water is the same both above and below the point of maximum density." But, when he comes to determine this crucial point precisely, he goes wide of the mark, setting it at 36°.

These references may enable us to grasp his manner of approach to a problem, and to realize his general plan of attack upon the atomic constitution of matter as it stood when he entered the field.

I wish that space permitted me to present some consecutive account of the doctrine of "matter" as it developed down the ages—but this is impossible. The subject deserves attention, because so bemused in the minds of the laity. And not only this. Scientific men themselves misconceive it at times, not deliberately indeed, but because, absorbed in researches of immediate moment, they have not troubled to follow the marvelous story with patience. The long, tortuous endeavors that culminated in Dalton's atomic theory, with its kernel, the law of multiple ratios, are the tale of man's attempt to reduce his notion of "matter" to *conceptual* simplicity; this to the end that it might be rendered an obedient instrument. Freed from contingent accessories, the central problem was this: Given such a vast multiplicity and variety of phenomena as the "substantial" world presents, how can all be grasped under a single, synthetic idea? Plainly, whenever man began to reflect upon nature, he encountered this sphinx. The elusive, yet persistent, relationship between the one and the many forms part of ancient history in science no less than in metaphysics.

Now, stating the situation very synoptically, and omitting the metaphysical reference in favor of the natural-scientific, it may be affirmed that the problem itself is also a many in a one. For, if we are to reach clear concepts about natural phenomena, we must reckon with three investigations at least. In the first place, a particular phenomenon must be selected, and treated as the starting point. This done, it is requisite to obtain an all-round view of *what* it is. In the second place, one must proceed to elucidate its relations to other phenomena, preferably to those which evince evident, or apparent, kinship. In the third place, order must be induced in the relations that have thus come under observation by reducing them, as far as possible, to numerical expression. The primary methods of weighing, measuring and enumeration

[15] *Ibid.*, p. 385.

must be invoked. This achieved, we may assert that we have arrived at that species of conceptual simplicity which we call a "law of nature." On a broad view, it is fair to say that, prior to Dalton, investigation and fancy pursued the one (*i. e.,* the conception of "matter") through the many (*i. e.,* these three aspects of the problem). For, on the whole, till we come to J. J. Becher (1635–82) and G. E. Stahl (1660–1734), the element theory held the field. And this is only to affirm that men were trying to master the properties of particular bodies, while reserving the remoter question of the ultimate constitution of "matter." Roger Bacon's view, probably the least fantastic we possess, is exceedingly significant of this.

> There are four Elements—fire, water, air, earth; that is, the properties of their condition are four—heat, coldness, dryness and wetness; and hyle is the thing in which there is nor heat, nor coldness, nor dryness, nor wetness, and a body is not. And the Elements are made of hyle; and each of the elements is transmuted into the nature of the other element and everything into everything else. For barley is a horse by virtual possibility, that is, occult nature; and wheat is a man by virtual possibility, and a man is wheat by virtual possibility.

The age of phlogiston, with its theories of combustion, marks a move to the second question. Men are now engaged in an effort to relate phenomena. Or, as Stahl puts it, in his conspectus: Combustible substance *minus* phlogiston is burnt substance—*e. g.,* metals, sulphur, phosphorus, etc., *minus* phlogiston, are metal calxes, sulphuric and phosphoric acids, etc. On the other hand, burnt substance *plus* phlogiston is combustible substance—*e. g.,* metal calxes, sulphuric and phosphoric acids, *plus* phlogiston supplied by carbon, are metals, sulphur, phosphorus, etc. In a word, the most different phenomena, such as the burning of carbon and the calcination of a metal, are shown to belong to the same class, and to be explicable by a simple conceptual hypothesis. Finally, when Lavoisier sent phlogiston by the board, the third question came to the fore, and men began to ask, How can we weigh, measure and enumerate the exact degree of relationship between the properties of substances? Dalton ranks among the great epoch-makers, because he first brought this inquiry within the range of practicable *uniformity.*

Discussions about prior discovery, over which much time and no little temper have been expended, prove profitless affairs, as a rule. You see, error and loyalty are human. For instance, I am well aware that scientific chemistry is dated usually from 1776, when Lavoisier made the balance *the* chemical instrument: but you will bear with Sadler[16] and me if we travel a little farther back and, as loyal sons of alma mater, find the initial point in the classical investigation of latent heat, conducted by Black between 1759 and 1763, at Glasgow. Nevertheless, as Dalton's priority has been impugned, we are bound to consider the facts.

[16] Herbert C. Sadler, professor of naval architecture.

Of course, every one knows that the conception of the discontinuity of "matter" appears in ancient history. And, when we descend to modern times, Boyle (1627–91) speaks of corpuscles, Boerhaave (1668–1738), Albrecht von Haller's master, of *massulæ*. Moreover, Dalton was a youth of only seventeen when the most important developments occurred. First, and with special reference to the framework of possible method, we have Lavoisier's (1743–94) celebrated memoir, "Reflections concerning Phlogiston," where he dismisses the dominant theory in sarcastic terms,[17] and establishes the *quantitative* method on a firm basis. In the same year (1783) Bergman (1735–84), the last of the great phlogistic chemists, published his notable work on what he called "elective attraction" (*i. e.*, affinity), a phenomenon attributed by him to the attraction between the most minute particles. Naturally, Bergman's table of "single elective attractions in the moist way, and in the dry way," with its curious alchemical signs, was a description of *qualitative* relations. It marked the beginning of investigation of mass action, and provoked the striking researches of Berthollet (1748–1822), who, in 1799, presented his paper, "Recherches sur les lois de l'affinité," out of which grew his major work, "Essai de statique chimique" (1803). The main result of his assault upon Bergman was to show that chemical change depends, not merely upon the affinities of the substances involved, but upon their *quantities*. In other words, a new method asserted itself. For, as Berthollet says:

> To find the affinity of two substances towards a third, in accordance with the conception we have now gained of affinity, can mean nothing other than to determine the *ratio* in which this third substance divides itself between the two first.

Therefore, chemical change hinges upon the nature of the relative *masses* of the substances involved, but, "to determine the ratio of the affinities of two substances towards a third . . . is attended by unsurmountable obstacles." Here was the blank wall, so to speak, that shadowed Berthollet's services till the time of Guldberg and Waage (1864). As Berthollet stood to Bergman, so did Proust (1755–1826) to Berthollet. Baffled in every attempt to determine the distribution of salts in solution, Berthollet had good reason to doubt the doctrine of constant composition. Here was Proust's opportunity. Having distinguished between "combinations of elements" and "associations of combinations," the latter variable under analysis, Proust was able to enunciate the law of fixed proportions—in his own words, "Election and proportion [*i. e.*, affinity and fixity of composition] are the two poles about which revolves immutably the whole system of true compounds, whether produced by Nature or by Man"; or, as Lothar Meyer phrases it, "Definite chemical compounds always contain their con-

[17] Cf. "Œuvres," Vol. II., pp. 623 f.

stituents in *fixed* and *invariable* proportions." Notice, in the words I have italicized, the unanimous trend towards *quantitative* measurements and accuracy, the ruling notion being that of *numerical ratio.*

We come to closer quarters with our central theme in the work of Richter (1762–1807), an investigator, it is important to note, obsessed by mathematical methods. Despite his obvious idiosyncrasy, Richter arrived at the law of equivalent ratios—"The qualities of acids and bases equivalent in one neutralization are equivalent in all." In 1802 Fischer made Richter's conclusions known to Berthollet, and chemical ratios became an integral part of the science. As Wollaston says, in 1814:

> It is to Richter we are originally indebted for the possibility of representing the proportions in which the different substances unite with each other in such terms that the *same substance* shall always be represented by the *same number.* He discovered the law of permanent proportions.[18]

The experimental proof was clinched by Berzelius in 1811–12, and the law of "permanent" or "definite" ratios, as it is called now, put the problem of composition on a practicable footing.[19] It should be noted also that, in stating the numerical values of the elements, Dalton employed some determinations of other chemists, at all events as checks.

We are now in a position to see that series of complicated researches, all looking to *quantitative* results, furnished Dalton with material which enabled him to render the atomic theory perspicuous and applicable from the very outset. Notwithstanding, to him must be given sole credit for the final simplification, which had been exercising his mind for some eighteen years—since 1790, in fact. A quotation from Berthollet's "Essai" (1803) may suffice to emphasize the long step due to Dalton's insight.

> Some chemists, influenced by having found determinate proportions in several combinations, have frequently considered it as a general law that combinations should be formed in invariable proportions; so that, according to them, when a neutral salt acquires an excess of acid or alkali, the homogeneous substance resulting from it is a solution of the neutral salt in a portion of the free acid or alkali. This is a hypothesis which has no foundation, but a distinction between solution and combination.[20]

Undoubtedly, events tended towards the new climate of opinion, nay, this had become so far prevalent that the Irishman, William Higgins (17?–1825) came nigh playing Wallace to Dalton's Darwin. Indeed, in 1814, he raised a claim to priority, which was disproved at once by Thomson, the Glasgow chemist who had made Dalton known. This Higgins is to be distinguished from his uncle, Bryan Higgins

[18] The italics are mine.

[19] Reference should be made to the classical experiments in further confirmation by Stas (1865).

[20] Cf. Lambert's English translation, p. 39.

(1737–1820), who, in 1775, in a prospectus of lectures, proposed to discourse of "his notions and experiments concerning the primary elements and properties of matter," and of "experiments, observations and arguments, persuading that each primary element consists of atoms homogeneal: that these atoms are impenetrable, immutable in figure, inconvertible, and that, in the ordinary course of nature, they are not annihilated, nor newly created." He also conceived of atoms, of simple particles, and even of gases, as uniting *sometimes,* in approximately, if not completely, fixed proportions. Yet, he never arrived at true causes, because his experiments failed to dove-tail with his advanced theoretical suggestions. Accordingly, the explicit variety of the former destroyed the implicit unity of the latter, and the *status quo ante* was maintained.[21] William Higgins, the claimant of 1814, published his book[22] in 1789. It contains forecasts of the atomic theory, such as the following:

I am likewise of opinion that every primary particle of phlogisticated air is united to two of dephlogisticated air, and that these molecules are surrounded with one common atmosphere of fire.[23]

But, after all, less than a dozen pages of the 300 deal with the subject; and, although he assigned causes for definite proportion and saturation in a few cases, he never suspected a simple, universal and necessary law. His real acuteness led him to see that combining particles had the same weight (multiple proportions), but he missed his chance to generalize in a maze of suspicions directed against the phlogistic theory, which had already lost its primacy; his indolence also hindered him, like his eccentricity.

III

Finally, coming to Dalton's characteristics as a thinker, we may find the clue in his forcible independence. In the preface to Part II. of "A New System of Chemical Philosophy" (1810), he declares:

Having been in my progress so often misled, by taking for granted the results of others, I have determined to write as little as possible but what I can attest by my own experience. On this account, the following work will be found to contain more original facts and experiments, than any other of its size, on the elementary principles of chemistry.

Here the strong man places himself on record, and the question of priority takes to flight. Accordingly, I state it as my clear impression that the merits and defects of his achievement are alike traceable to the fact that our laureate lay under direct obligation to but one of his

[21] His chief work is, "Experiments and Observations relating to Acetous Acid, Fixable Air, Dense Inflammable Air, Oils and Fuel, etc." (1786).

[22] "A Comparative View of the Phlogistic and Antiphlogistic Theories, with Inductions, etc."

[23] P. 132 (2d ed., 1791).

predecessors—Newton. Dalton encountered certain phenomena, such as multiple and definite proportion, aqueous vapor as a distinct constituent of air, and, seeking for the simplest common representation, found it in Newton's well-known doctrine. For example, he says:

> According to this view of the subject [heat], every atom has an atmosphere of heat around it, in the same manner as the earth or any other planet has its atmosphere of air surrounding it, which can not certainly be said to be held by chemical affinity, but by a species of attraction of a very different kind.[24]

And he quotes from Newton:

> All bodies seem to be composed of hard particles. . . . Even the rays of light seem to be *hard* bodies, and how such very hard particles which are only laid together and touch only in a few points, can stick together, and that so firmly as they do, without the assistance of something which causes them to be attracted or pressed towards one another, is very difficult to conceive.[25]

This was the secret of the opposition of Hope and, later, of Faraday's complaint. In a letter, dated January 2, 1811, Hope wrote to Dalton as follows:

> I need not conceal from you that I am by no means a convert to your doctrine, and do not approve of putting the result of speculative reasoning as experiment.

While Faraday, similarly suspicious, as late as 1844, said:

> The word atom, which can never be used without involving much that is purely hypothetical, is often *intended* to be used to express a simple fact. . . . There can be no doubt that the words definite proportions, equivalents, primes, etc., . . . did not express the hypothesis as well as the fact.[26]

The truth is that Dalton was a first-rate theorist, who arrived at his conclusions, not primarily on the basis of induction from experiment, but by reflection. Analogically, he imports the view of "matter" peculiar to celestial mechanics, through molecular physics, into the realm of chemistry. Proceeding thus deductively, he evinces little awareness of the very complex problems involved, which the later developments of the atomic theory were to reveal. Cut off from the world, he did not possess intimate acquaintance in detail with the labors of his immediate predecessors and contemporaries—a happy accident, no doubt. For, this freedom from puzzle and disturbance enabled him to proceed boldly with a generalization when men of the caliber of Wollaston and Davy hung back. Dalton had natural capacity for logical thought, and complete confidence in the validity of those mathematical syntheses of *physical* facts which he had pondered.

But, as happens frequently, his limitations are traceable to the same source. Like Kant before him, Dalton became so entangled in the theoretical ways of his own thought that, after he had promulgated his

[24] *Manchester Memoirs*, Vol. II. (2d series), pp. 287 f.

[25] Royal Institution Lecture Notes.

[26] "Experimental Researches," Vol. II., pp. 285 f.

theory, he stopped short in middle life, and could not appreciate the work of others who followed and supported him. This is the blot on his 'scutcheon. Still, even so, we must hold the balance true. The kinetic doctrine of "matter," integral to the Cartesian philosophy, had paled before Newtonian atomism. And Dalton had grasped Newton's view so logically that he could not admit the law of equal volumes, because, as he held, "no two elastic bodies agree in the size of their particles." The very success of his hypothesis blinded him to Gay-Lussac's experimental evidence—it would not conform to the conceptual scheme. As he wrote to Berzelius, in September, 1812:

> The French doctrine of *equal measures* of gases combining, etc., is what I do not admit, *understanding it in a mathematical sense.* At the same time I acknowledge there is something wonderful in the frequency of the approximation.[27]

Of course, the fact was that, as Wurz points out,

> The relation which exists between the densities of gases and their atomic weights is not so simple as we should at first sight be led to expect, and as for a long time it was thought to be.[28]

Nay, "understanding it in a mathematical sense," Dalton had his reasons. By a kind of paradox, the very simplicity of his notion befogged him here, just as the problems bred of the atomic theory diverted chemists for many a long day from the study of affinity.

We may conclude, then, that the logical character of Dalton's mind enabled him to formulate the timely conceptual representation on which chemical logic has pivoted ever since; that his numerical conception has stood the test of further discovery better than most hypotheses; and that, little as he knew it, or could admit it at the moment, he laid the foundation for that intimate alliance between physics and chemistry which forms one of the most pregnant among contemporary movements. For, the active criticism of the atomic theory—that it dogmatizes about the physical constants marking the differences between the elements, that it reveals little or nothing of the *processes* incident to chemical composition and destruction, that it neglects synthesis—testifies also, if negatively, to the revolution wrought by its author. Pity is akin to praise here. And to-night, as we celebrate Dalton's "thoughts that breathe," we are bound to let praise have its free way, especially when we contemplate the indomitable devotion of a character who, amid sore difficulties, but furnished with the splendid spur of consecration to the ideal, achieved so much for man's conquest of the secrets of nature.

[27] The italics "understanding," etc., are mine.

[28] "The Atomic Theory," p. 35 (English translation).

ALEXANDER AGASSIZ.

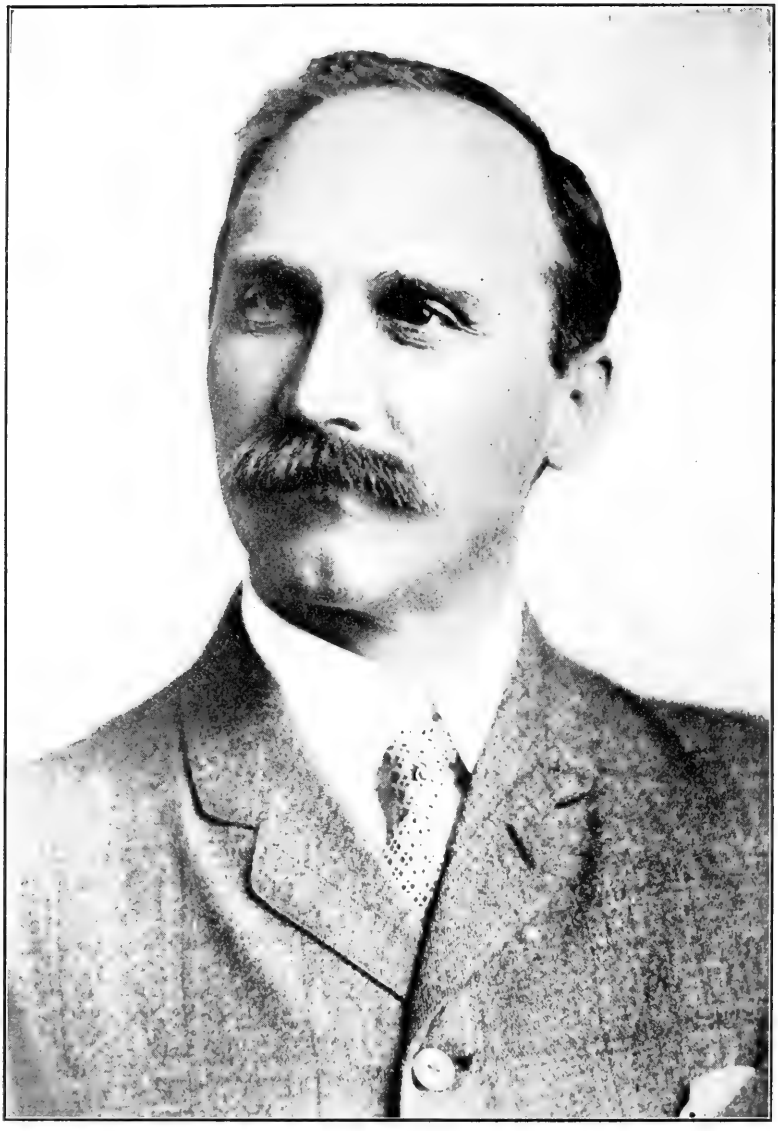
THE PROGRESS OF SCIENCE

THE DEATH OF ALEXANDER AGASSIZ

In the death of Alexander Agassiz, America loses its foremost naturalist, as a few months ago in the death of Simon Newcomb it lost its most eminent representative of the exact sciences. Both were born in the year 1835, and in a century preeminent for science both gave distinction to this country when it was relatively backward in scientific productivity. Each maintained his intellectual leadership and continued his researches and publications to the very end of a long life. America is no longer behind the nations of Europe in the number of its scientific workers, but among them all are none to take the places left vacant by Agassiz and Newcomb.

Alexander Agassiz was endowed at birth with the heritage of his great father, Louis Agassiz, whose work at Harvard he carried forward. Born in Switzerland, he came to the United States in 1849 at the age of fourteen and graduated from Harvard College in 1855, continuing graduate studies in mining and chemistry in the Lawrence Scientific School. In 1859 he went to California as an assistant on the coast survey and in the following year became assistant in the museum founded by Louis Agassiz, during whose absence in Brazil he was in charge. From 1866 to 1869 he was engaged in mining in the Lake Superior region and became superintendent of the Calumet and Hecla copper mines of which he was president at the time of his death. He thus acquired abundant wealth, and was able to give more than half a million dollars to the Harvard Museum of Comparative Zoology and to conduct as he wished his oceanographical expeditions.

In 1869 Mr. Agassiz visited European museums and on his return in 1870 renewed his duties at the Harvard Museum, of which he became curator and director on the death of Louis Agassiz in 1873. He was for a series of years one of the seven fellows who form the corporation of Harvard College, and was on two occasions elected an overseer. In 1875 he visited the western coast of South America and subsequently went to England to assist with the reports of the *Challenger* expedition, writing the monograph on the Echini. Previously and subsequently to the end of his life, he made a great number of valuable scientific contributions to marine zoology, the embryology of fishes and coral reefs. In awarding to him its Victoria research medal, the report of the Royal Geographical Society said "he has done more for oceanographical research than any other single individual" and summed up his work by noting that for thirty years he had carried out personally oceanographical expeditions over most of the oceans of the world. In 1877–80 he explored the Florida Straits and Gulf of Mexico, the Atlantic Coast and the Caribbean Sea. In 1880 he studied the surface fauna of the Gulf Stream; in 1892–4 he investigated the Sandwich Islands, studying recent and extinct reefs. In 1891 he conducted three cruises off the West Coast of Central America, and in 1895–6 he studied the Great Barrier Reef of Australia and in 1897–8 the Fiji Islands. In 1899–1900 he carried out a cruise from San Francisco via the Coral Island groups to Japan. In 1904–5 he investigated the eastern tropical Pacific. In the Indian Ocean in 1901–2 he devoted himself to the Maldive Islands. In 1874–5 he investi-



Charles Reid Barnes.

gated Lake Titicaca. Mr. Agassiz has done this entirely at his own expense. The results have been published by him through the Museum of Comparative Zoology at Harvard College, in thirty volumes of memoirs and fifty-three volumes of bulletins, mostly containing the results of his own various expeditions and of the work of the specialists who examined his collections. Besides the numerous publications through the Harvard Museum, in 1888 Mr. Agassiz published in two volumes the narrative of his three cruises in the Gulf of Mexico, the Caribbean Sea, and along the Atlantic Coast of the United States, with charts and illustrations.

Mr. Agassiz had been president of the National Academy of Sciences, and was a foreign member of the leading academies of the world. He was not only the author of important contributions to science, but was also a great man, possessed of complete courage and frankness and a dominant will, which gave him leadership throughout the broad and rich experiences of his long life. As he was happy in his birth and in his life, it may be said that he was not ill-starred in his death, for he died with faculties undimmed, suddenly, on the sea, which he loved so well and had explored so persistently.

CHARLES REID BARNES

THE death of Dr. Charles Reid Barnes, professor of plant physiology at the University of Chicago, as the result of a fall, is a serious loss to botany. He was born at Madison, Ind., in 1858 and was educated at Hanover College and Harvard University. After occupying successively the chairs of natural history and of botany and geology at Purdue University, he was called to the chair of botany at the University of Wisconsin in 1887, where he remained until he took up his final work at Chicago in 1898. During all of these years he was associated with Professor Coulter in the editorship of the *Botanical Gazette*. Professor Barnes had served as vice-president of the botanical section of the American Association and as president of the Botanical Society of America. Professor Barnes's best known earlier publications dealt with the taxonomy of mosses. Just before his death he completed the final proof-reading of the physiological part of a general textbook of botany that is expected soon to appear from the Hull Botanical Laboratory. Within the past few years Professor Barnes had become greatly interested in morphological problems among the bryophytes, two papers having been already published in conjunction with Dr. Land and several others being partly ready.

THE TROUBLES AT PRINCETON

THE secret history of almost any American university is not less complicated than recent events at Princeton, but it is certainly unusual for such family quarrels to be so completely exploited before a public which can scarcely be expected to understand them. It is, however, probably not a bad thing for a university to conduct its affairs in the open and for large numbers to become interested in them, even though the principles involved may not be so vital as they appear to those immediately concerned. Probably the circumstance of greatest general interest at Princeton is the control exercised by the alumni. This is a factor likely to become increasingly important in the history of our universities, and it is not without its dangers, for the alumni bear gifts and are more likely to be concerned with athletics and fraternities than with scholarship.

The outlines of the Princeton story are now common property. Dean West has long urged with enthusiasm a graduate college on the lines of the Oxford colleges and President Wilson approved the plan. Then came President Wilson's move against the clubs—fraternities are forbidden at Princeton—and in favor of more democratic "quads," which divided the faculty and trustees and awakened the opposition

LIEUTENANT ERNEST SHACKLETON,
the eminent arctic explorer, who is at present lecturing in the United States.

of the rich alumni. The Swan bequest of $300,000 for a graduate college then became available, and there was difference of opinion as to its site. Mr. W. C. Proctor at this stage offered to give $500,000 for the graduate college as planned by Dean West and on condition that an equal sum should be subscribed by others. There was again difference of opinion as to the site and the control of the college, and while the president and a committee of the trustees were trying to come to an agreement with Mr. Proctor, he withdrew his gift.

The question of site is somewhat trivial except in so far as it has become identified with policies. Whether the residence hall should be in the midst of the Princeton campus or on its outskirts can not be a matter of serious consequence. The fact is that the president of the university and some of the trustees were unwilling to place the dean of the graduate school in as complete control of its development as the acceptance of Mr. Proctor's gift might have implied. The real trouble is one of men rather than of measures.

It is a curious circumstance that President Wilson and Dean West are in pretty close agreement in favor of a financial democracy and of an intellectual aristocracy or snobbishness, as one may please to call it. When Dean West favors a residential college with oak-panelled dining hall in which the students shall dine in evening dress, he does so because he wishes to give the young men without money a chance to live in the environment which he regards as proper to the scholar and the gentleman. The ideal of such a college was well put in an address made some years ago. We read of

> a place removed—calm Science seated there, recluse, ascetic, like a nun, not knowing that the world passes, not caring, if the truth but come in answer to her prayer; and Literature, walking within her open doors, in quiet chambers, with men of olden time, storied walls about her, and calm voices infinitely sweet; here "magic casements, opening on the foam of perilous seas, in fairy lands forlorn," to which you may withdraw and use your youth for pleasure.

Those who have followed the recent Princeton controversy may be surprised to learn that this not a quotation from Dean West, but from the concluding part of Dr. Wilson's address on the occasion of the Princeton sesquicentennial celebration. It might be that President Wilson had learned new things in the meanwhile, but at the meeting of the Association of American Universities a couple of months ago, he presented a paper urging the old ideas of amateurism and dilletantism in college studies. He writes:

> All specialism—and this includes professional training—is clearly individualistic in its object; that is, the object of professional training is the private object of the person who is seeking that training. . . . The minute professionalism enters learning, it ceases to wear the broad and genial face of learning. It has become a commodity; it has become something that a man wishes to exchange for means of support. It has become something that a man wishes to use in order to get the better of his fellowmen; to enhance his fortunes; to do all the things that center in and upon himself; and it is professionalism that spoils the game, the game of life, the game of humanity, the game of cooperation in social undertaking, the whole handsome game that we are seeking to throw light upon by the processes of education.

It is a remarkable and interesting fact that Princeton is becoming a great university and a great scientific center almost in spite of those in control. The large gifts made to the university have found their way to build fine laboratories and to secure scientific men of the first rank. The preceptors intended for less modern purposes brought to Princeton a large group of younger men from various institutions who have given it new life. The efforts for a graduate residential college, which in Dean West's words should "show that God is the end of all our knowing and

Christ is the Master of the Schools," or, in President Wilson's phrase, should be "quick to look toward heaven for the confirmation of its hope," will lead to a true graduate school for the training of professional scholars and the advancement of knowledge.

SCIENTIFIC ITEMS

We regret to record the deaths of Professor Robert Parr Whitfield, curator of geology of the American Museum of Natural History; Dr. Borden Parker Bowne, professor of philosophy at Boston University, and of Dr. Eduard Pflüger, the eminent German physiologist.

Dr. T. Muir, F.R.S., has been elected president of the South African Association for the Advancement of Science for the meeting in Cape Town, the date of which is not yet set.—Dr. George W. Hill, of Nyack, N. Y., and Professor E. B. Wilson, of Columbia University, have been elected foreign members of the Brussels Academy of Sciences.—A testimonial dinner to Dr. Charles Frederick Chandler was given at the Waldorf-Astoria on April 2, to permit his former students and associates to express, before his retirement, their appreciation of his forty-six years of service to Columbia University, and his lifetime of devotion to the cause of education and science. It was announced that a lectureship in honor of Dr. Chandler would be endowed by his former students and that the chemical museum of the university would be named in his honor.

The Oceanographical Museum at Monaco, established by the Prince of Monaco, was opened on March 29. The different European governments and the principal scientific societies were represented at the ceremony.—A Brooklyn Botanic Garden is now being established by the City of Greater New York in cooperation with the Brooklyn Institute of Arts and Sciences. Between twenty-five and thirty acres of land, south of the museum building of the institute in Brooklyn, have been set apart for the purposes of the garden. A laboratory building for purposes of investigation and instruction, together with a range of experimental and public greenhouses, will be constructed during the coming summer and autumn. For this purpose the City of New York has appropriated $100,000 and friends of the garden in Brooklyn have subscribed $50,000 as an endowment. Dr. C. Stuart Gager, professor of botany in the University of Missouri, has been appointed director.

THE
POPULAR SCIENCE
MONTHLY.

DECEMBER, 1910

THE ILONGOT OR IBILAO OF LUZON

By Dr. DAVID P. BARROWS
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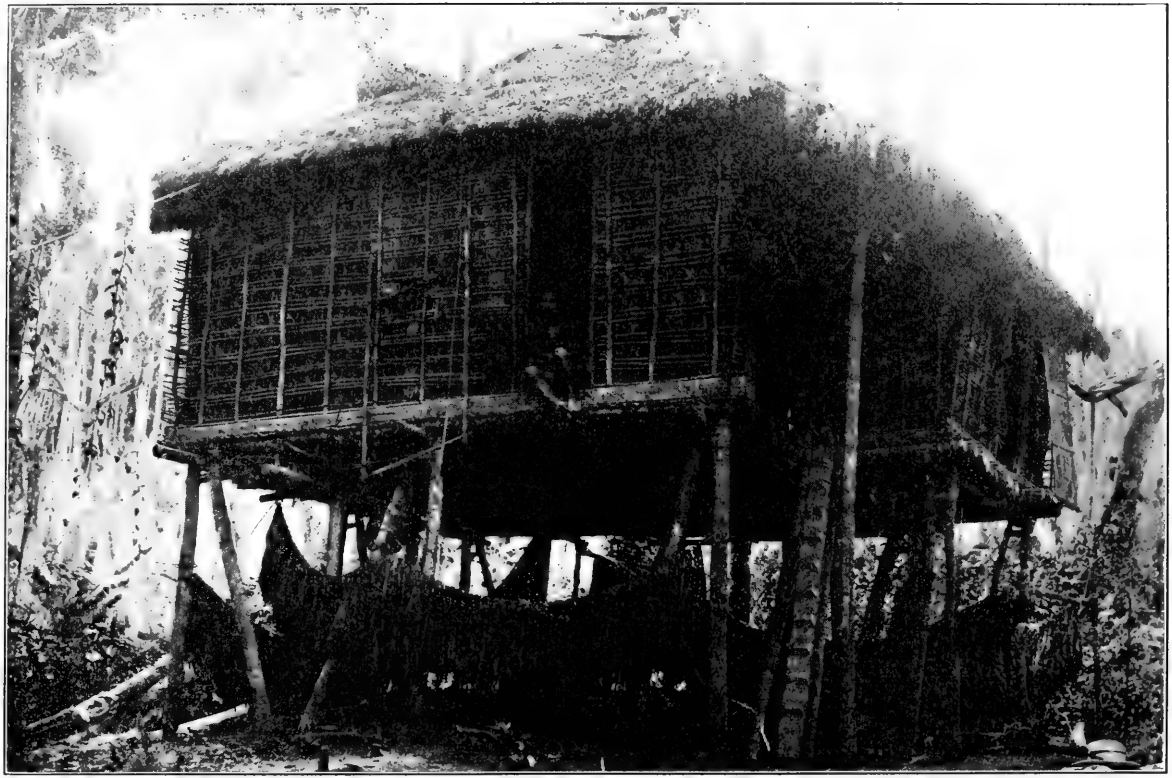
THE grewsome practise of taking human heads is particularly associated with the Igorot peoples of the Cordillera of Luzon. These all engage in it or have done so until recently. But to-day the most persistent and dreaded headhunters are neither Igorot nor inhabitants of the Cordillera; they are a wild, forest-dwelling people in the broken and almost impenetrable mountain region formed by the junction of the Sierra Madre range with the Caraballo Sur. They have been called by different names by the peoples contiguous to them on the north, west and south, "Italon," "Ibilao," "Ilongot" or "Ilūngūt." The last designation would for some reasons be the preferred, but "Ibilao," or as it is quite commonly pronounced locally through northern Nueva Ecija, "Abilao," has perhaps the widest use.[1]

There are no early records of these people and until late in his rule the Spaniard knew almost nothing of them. In the latter half of the eighteenth century, the valley of the Magat was occupied and the mission of Ituy founded, out of which came the province of Nueva Vizcaya, with its converted population of Gaddang and Isinay. To reach Ituy from the south the trail followed up the valley of the Rio Pampanga almost to its sources and then climbed over the Caraballo Sur to the headwaters of the Magat. On this trail along the upper waters of the Pampanga grew up several small mission stations, Pantabangan and Karanglan, with a population of Pampanga and Tagalog people drawn from the provinces to the south. After more than a hundred years these small towns are still almost the only Christian settlements in

[1] The report of these people under different names has been the cause of the belief that they were so many separate peoples. Professor F. Blumentritt makes this mistake. "Versuch einer Ethnographie der Philippinen," p. 33; "List of Native Tribes of the Philippines," translated in Smithsonian Report for 1899.



AN ILONGOT AT OYAO, NUEVA VIZCAYA.

Photograph taken in 1904. Tobacco is drying underneath the house. Behind the house stand the bare trees of the forest clearing.

northern Nueva Ecija. From the time of their establishment we find references to the "Ilongotes" who inhabited the mountains to the east and were spoken of as "savages," "treacherous murderers," "cannibals," and wholly untamable. Much as described a hundred years ago they have continued to the present day. Their homes are in thick mountain jungle where it is difficult to follow them, but, from time to time they steal out of the forests to fall upon the wayfarer or resident of the valley and leave him a beheaded and dismembered corpse.

Here are a few instances occurring in recent years which came under my own notice or investigation. In 1902, the presidente of Bambang, Nueva Vizcaya, informed me that four women had been killed while fishing a short distance from the town. In March of the same year, a party of Ilongot crossed the upper part of Nueva Ecija and in a barrio of San Quentin, Pangasinan, killed five people and took the heads of four. In November, 1901, near the barrio of Kita Kita, Nueva Ecija, an old man and two boys were killed, while a little earlier two men were attacked on the road above Karanglan, one killed and his head taken. In January, 1902, Mr. Thomson, the superintendent of schools, saw the bodies of two men and a woman on the road, six miles south of Karanglan, who had been killed only a few moments before. The heads of these victims had been taken and their breasts completely opened by a triangular excision, the apex at the collar bone and the lower points at the nipples, through which the heart and lungs had been removed and carried away. As late as a year ago (1909), on the trail to San José and Punkan, I saw the spot where shortly before four men were murdered by Ilongot from the "Biruk district." These men were carrying two large cans of "bino" or native distilled liquor, from which the Ilongot imbibed, with the result that three of their party were found drunk on the trail and were captured. These are only a few out of numerous instances, but they explain why the great fertile plains of northern Nueva Ecija are undeveloped and why the few inhabitants dwell uneasy and apprehensive.

There have been no successful attempts to subdue or civilize these people. Between 1883 and 1893, the missionary friar, Francisco Eloriaga, founded the Mission of Binatangan in the forested hills east of Bayombong, and the Spanish government had the project of erecting it into a "politico-military commandancia," but so far as I know did not reach the point of sending there an officer and detachment. Something was learned about the most accessible Ibilao, but no permanent results followed.[2] Since the American occupation, however, progress has been made in our knowledge and control of this people. In October, 1902, the writer, at that time chief of the Bureau of Non-Christian

[2] A brief account of the people about Binatangan was published by a missionary in 1891 in "El Correo Sino-Annamita," Vol. XXV. "Una Visita á los Rancherias de Ilongotes," by Father Buenaventura Campa.

ILONGOT HUNTING PARTY.

Photograph taken near Delapin in Nueva Vizcaya in August, The large nets carried are stretched in the jungle across the game trails and the game are driven into them. The spears and bows and arrows represent their typical weapons. The curly headed man represents the mixed Malayan and Negrito type common in these people.

Tribes, and engaged in a preliminary reconnaissance of the pagan peoples of northern Luzon, made a trip with a small party to one of their communities in the mountains east of Bambang. Photographs, measurements and notes on their language and social institutions were made. In January, 1906, Mr. Dean C. Worcester, secretary of the interior, approached these people from the north, by ascending the Kagayan river. His party started from a station of the Tabacalera Company, south of Echague, and from there rode through fine forest to a "sitio" called Masaysayasaya. From here they "started at dawn and about noon passed the 'dead line' set by the Ilongotes. A little before sundown reached Dumabato, an Ilongote and Negrito settlement, which had been the headquarters of Sibley,[3] the deserter. Here were found a few filthy Ilongotes and some fine Negritos."

In the spring of 1908, Dr. William Jones, of the Field Columbian Museum, began a residence among the Ilongot of the upper Kagayan and lived with them continuously until nearly a year had passed, when he was killed by them. His notes and specimens were fortunately preserved and, when published, should constitute the most original and important contribution ever made to Philippine ethnology. Dr. Jones was part American Indian, a member of the Sac and Fox tribe. He was not only a brilliant scientist, but one of the most engaging and interesting men I have ever known—a man to cleave to. Here are brief extracts from two letters written by him from the Ibilao country, valuable, I think, not only for the information they contain about this people, but for the light they throw upon him and his manner of work.

May 26, 1908. I am at present among the Ilongotes of the Cagayan, where I am having the most enjoyable time since my arrival in the islands. These people are wilder than the Igorrotes. We made friends at the beginning and the friendship has grown wider and stronger every succeeding day. I have a shack high up on poles where I dwell with great comfort. And plenty of food is to be had always; wild hog and venison in the jungle on either side of the river; lurong and liesas in the river; wild honey back on the mountain side; bananas, beans, camote and other things from the cultivated patches, and rice which has been saved from last season. For the last fortnight the people have been clearing in the jungle for sementeras.[4] I wish you might hear the sweet melody of the songs of boys and women at work in the clearings, songs sung to the spirits of the trees and for good crops. Ilongot society is much simpler than that of the Igorote; there is little if any of what may be called village life. There is a house here, another yonder and so on here and there along the river. Places near the river are reached by going on balsas[5] and away from the river the trails are dim and indistinct. I do not know where I shall end up. I am heading up-stream. It may be that I shall find myself going west and southwest into the country of the Ilongotes, who are enemies of the ones I am now

[3] Sibley was an American soldier from the 16th Infantry who deserted in 1900, and lived for over four years, a renegade among these people. He finally surrendered to Governor Curry, of Isabela province.

[4] Fields for seeding.

[5] Cane rafts.

Ilongot Men and Woman of Oyao, Nueva Vizcaya.
The man on the right wears a characteristic head cover of rattan, which confines his long hair.

with. I have to go much lighter than what I am now to keep up with the little black Negrito. He is like a flea; here to-day, there to-morrow, and ever on the move when food is gone, and at rest, when he has a supply, long enough to consume it. He is at outs with the particular people I am with at present.

Kagadyangan, on the Cagayan, Isabela. July, about the 12, 1908. I am compelled by force of circumstances to continue in this field for three or four months more; at least that much time must pass before I can observe a full cycle of the various activities of these people. Furthermore, the rainy season sets in about September and it is difficult ascending in this region where the rapids are numerous and swift. . . . I have come upon Ilongote habitations in cliff and rock shelters. Why might their ancestors or those of others not have lived in such in ages past and left evidences of an earlier culture? Many Ifugao burials are in sepulchres on mountain sides and the practise is no doubt very old. Places like these and those of rock shelters in other lands have given fruitful results and might they not in these islands?[6] I am having a pleasant time with these people. They are the wildest of any people that I have yet come across in Luzon. But like all wild people, they are cordial and hospitable. I live in their houses and so have their presence day and night. I hunt, fish and hike with them, see them on and off their guard, observe them in all their varying moods—in short, I'm very close to them all the time. Some time I will tell you a thing or two about them.

Alas, for his intimacy and confidence in them! Alas, that so gifted and lovable a man should have been lost by their treachery to science and to his friends!

From the Nueva Vizcaya side considerable progress has been made in the acquaintance and control of these people. For several years, Mr. Conner, the superintendent of schools, cultivated their friendship and gained information that led to his successor, Mr. R. J. Murphy, organizing a school in the community of Makebengat. The method followed was to hire a very trustworthy and capable Filipino of the town of Bambang who speaks their language and has had friendly relations with them, to go out and dwell with them, persuading and hiring them to build a good dwelling house for the teacher, a school house and shop, and to bring their own dwellings into the locality fixed upon for the school. Then there were sent out two native teachers (one a woman, capable of teaching spinning and loom weaving), to begin the instruction of the children in language, figuring and in industrial arts not known to the Ilongot. This school experiment promises to succeed and has already led to starting one or two other schools in communities still more distant in the forest.

Governor Bryant, of the province, has felt much interest in these people, and two years ago performed the very difficult feat of traversing the forests from these first communities northward to the province of Isabela. This hazardous exploration occupied about two weeks before

[6] The Ifugao are an Igorot people inhabiting the Kiangan region. All the Igorot people practise, wherever possible, the burial of their rich and important personages in caves and artificial grottos. Burial caves occur in many places in the Philippines and have yielded a large store of jars, skulls and ornaments.

the party emerged from the forest into the open country. The greatest difficulty and peril was lack of food, which can not be carried in sufficient quantities to sustain the entire journey.

In January, 1909, a very important exploration was made by Governor Bryant, escorted by Captain Hunt with a detachment of soldiers, and accompanied by Mr. Murphy and Dr. M. L. Miller, chief of the ethnological survey. The party left Dupah, January 7, and traversed the wholly unknown country lying to the southwest. The course of the wild gorge of the "Kaseknan" river, the head of the Kagayan, was developed, several important communities of Ilongot were discovered and visited without hostilities and the first knowledge obtained of much of this region. After struggling for ten days with the difficulties of jungle, ravine and densely covered mountains, the party reached Baler on the Pacific coast.

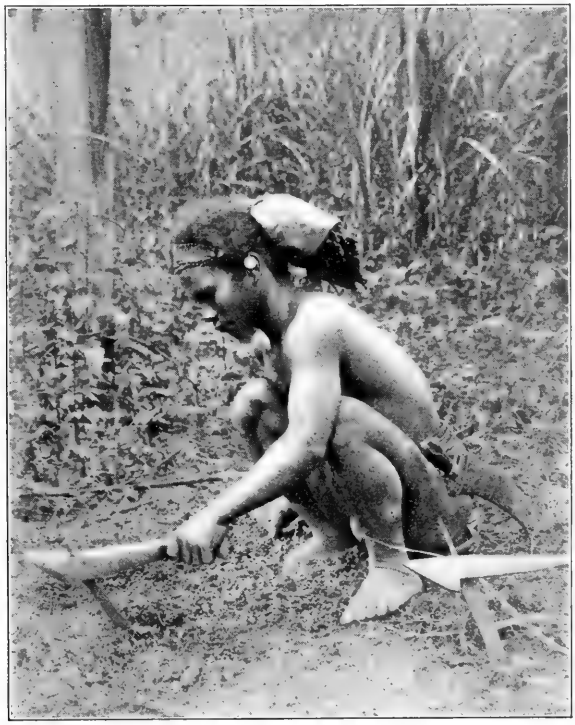
In May, 1909, the writer, accompanied by Lieutenant Coon and six native soldiers, reached a small community of Ilongot east of Pantabangan, called "Patakgao." This community seemed to be composed of renegades and outlaws from several other communities. Certainly their hand was against every man. They were charged by a small group of Ilongot living near Pantabangan with the murder of two of their number a few weeks earlier and they themselves professed to be harried and persecuted by unfriendly Ilongot to the north and east of them. They had wounds to exhibit received in a chance fray a few days before with a hunting party from near Baler. Altogether, their wayward and hazardous life was a most interesting exhibit of the anarchy and retaliation that reign in primitive Malayan communities which are totally "in want of a common judge with authority." A series of measurements was obtained by me at Patagkao and vocabulary and notes extended.

With the above remarks as to what has been accomplished in throwing light upon these people some description of them will be given. For information of their location and condition I am indebted to several others, and particularly to Mr. Murphy, otherwise the facts are the results of my own investigation.

Ilongot can not be said to live in villages, for their houses are not closely grouped, but are scattered about within hallooing distance on the slopes of cañons where clearings have been made. Each little locality has its name and is usually occupied by families with blood or social ties between them, and several such localities within a few hours' travel of one another form a friendly group. Outside of this group all other Ilongot as well as all other peoples are blood enemies, to be hunted, murdered and decapitated as occasion permits.

The most considerable body of Ilongot appears to be those living east of the towns of Nueva Vizcaya from Mount Palali south, along a high-wooded range to the district of "Biruk," nearly east of Karanglan.

Here are some important occupied sites that go by the names of Kampote, Kanatwan, Kanadem, Makebengat, Oyao and Biruk, as well as others. Homes are shifted from time to time as new clearings have to be made, and the name of a community's home will vary and can not always be relied on. All of these communities seem to be in fairly friendly relations with one another, though they are not bound together by tribal or political ties. Southeast on the rough hillsides of the Kaseknan River, the country first traversed by Mr. Bryant's party in January, 1909, are several communities of very wild Ilongot, Sugak, Kumian and Dakgang. These places were greatly alarmed by the



AN ILONGOT MAN AT WORK IN CLEARING.

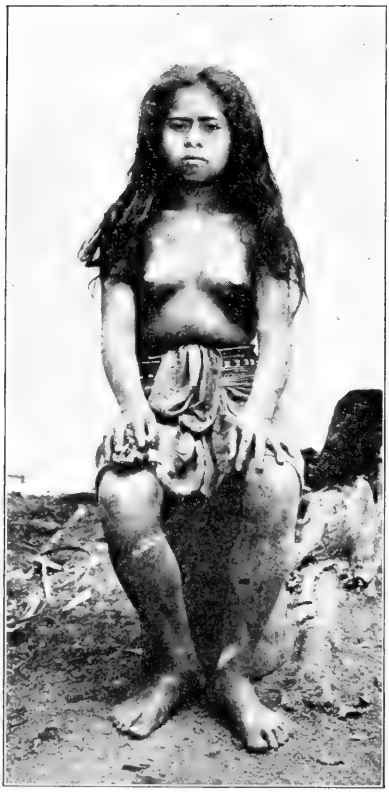
He wears the peculiarly shaped Ilongot knife, the usual head covering and a shell ear-ring. The wavy hair on head, face and limbs strongly suggests the Negrito.

approach of the party and used every effort to persuade it to pass without visiting at their houses. Conversations had to be held by shouting back and forth across deep gorges, and approach was very difficult. These people have scattered rancherias toward Baler and sustain trading relations with the Tagalog of that town, but are hostile with the Ilongot of the Nueva Vizcaya jurisdiction. Appurtenant to the towns of Karanglan and Pantabangan are a few minor communities, among them Patakgao. Finally, further north on the Rio Kaga-

yan, toward the province of Isabela, we have the Ilongot communities in which Dr. Jones worked, and lost his life, Dumabato, Kagadyangan and others. It may be that these Ilongot communicate with the Tagalog town of Kasiguran. In all of these communities together there are probably only a couple of thousand souls at most. Few communities have as many as twenty houses or 200 souls; the most are isolated groups of four or five married couples and their immediate relations. The harsh nature of their country, unsanitary life, occasional epidemics and most of all their petual warfare contribute toward their diminution rather than their increase.

AN ILONGOT MAN OF BAYYAIT, NUEVA VIZCAYA.

The photograph shows the curious deer skin cape and hat worn by the men when hunting or traveling in the rain.



A YOUNG WOMAN OF OYAO, NUEVA VIZCAYA.

Photograph taken in 1904.

Like other primitive Malayan people who live in the forest, the Ilongot support life by cultivating a forest clearing or "kaingin." The great trees are girdled, men ascend their smooth clean trunks a hundred feet or more and daringly lop away their branches and stems that the life of the tree may be destroyed and the sunlight be admitted to the earth below. At Patakgao I was shown some beautiful long

pieces of the rattan an inch and a half in diameter with elaborately woven loops at the ends. These are swung from one tree top to another and serve as passage-ways for the men at work. To cross they stand on the slack cable, one hand grasping it on each side, and so, crouching, pass along it at a height above the ground of 80 to 100 feet. With this in mind, I could understand their replying to my inquiry as to when they prayed, by saying that they "prayed and sang to the spirits when they went to climb the trees." Their crops are mountain rice, camotes or sweet potatoes, gabi or taro, maize, squash, bananas, tapioca and, in some places, sugar cane and tobacco. They are good gardeners, although all their cultivation is by hand, their tools being a short hoe or trowel and a wooden planting stick, which is ornamented with very tasteful carving.

The houses of the Ilongot are of two sorts. Sometimes they are low wretched hovels, built two or three feet above the ground, with roofs of grass and sides of bark. But frequently the Ilongot build really well-constructed and creditable homes. These are set high above the ground, fully twelve feet, on a large number of posts or piles; the floor is made of carefully set strips of palma brava, the door-posts, lintels and exposed pieces of framework are curiously and tastefully carved. Such a dwelling is built large and spacious for the occupancy of several families and there is usually a hearth in each of the four corners of the big, single room. Such a house set on a conspicuous ridge and lifted by its piles high among the foliage of the surrounding jungle is a striking and almost an imposing sight.

The arms of the Ilongot are the spear, the jungle knife which they forge into a peculiar form, wide and curving at the point, a slender, bent shield of light wood and the bow and arrow. The use of the latter weapons is significant and here, as always in Malaysia, it indicates Negrito influence and mixture. They use a bow of palma brava and the ingenious jointed arrow of the Negrito with point attached by a long cord of rattan to the shaft, which separates and dragging behind the transfixed animal impedes his escape.

Both men and women wear the long rattan waist belt wound many times about the loins with clouts and skirts of beaten bark cloth. The men also use a curious rain hat not unlike a fireman's helmet, made of rattan and deerskin, the light frame neatly decorated with carving, and a deerskin rain coat to cover their backs in the dripping forest.

The physical type of the Ilongot is peculiar and rather unlike that of any other Philippine people. The men are small, with long bodies and very short legs, weak, effeminate faces, occasionally bearded. The hair is worn long, but usually coiled upon the head and held by a rattan net. The color of the Ilongot is brown and a little lighter than that of Malayans exposed to the sun by life on the water or in the plain. Their head hair is sometimes nearly straight, usually wavy and occa-

ILONGOT MEN AND WOMEN CLEARING THE GROUND FOR RICE PLANTING.

The men have a characteristic trowel. The women have planting sticks of hard wood elaborately carved. The man with the curly head indicates the Negrito blood in these people.

sionally quite curly. These rather unusual characteristics of the Ilongot have led to some absurdly exaggerated reports of their appearance.

My measurements include 15 men, 8 women and a young boy whose stature is disregarded. The height of the men varied from 1,439 mm. to 1,610 mm., the mean being about 1,540, a very small stature though considerably above the Negrito. The stature of the women was from 1,386 mm. to 1,510 mm., the mean being about 1,440. The cephalic index of all but four of the 24 individuals was between 89 and 80 (brachycephalic), one was 79.9, two were 79, and one 76 (mesaticephalic). The nasal index of all but six varied from 100 to 87 (markedly platyrhinian), while the remaining six had indices from 83 to 76. The mean index of all was 88.6. The arm reach, as is usual in Negritic peoples, exceeded the height.

A peculiarity of the Ilongot face is that, while it is relatively wide at the cheek bones, it narrows rapidly below, giving the effect of a pentagonal shaped face with sharp chin. The eyes are relatively well opened and clear, like the eye of the Negrito, without slant or folding lid.

In the Ilongot then we have a small, shortlegged, wavy or curly-haired man, round headed generally, flat and broad nosed, with occasionally bearded face and restless nervous physiognomy. Most of these are not characteristics of the ordinary forest Malayan; on the contrary, they suggest the Negrito, and occasion the belief, in my own mind, that the Ilongot is, like many other peoples of the Philippines and Malaysia, a mixed race resulting from the union of Negrito and Malayan.

From what has already been said it is apparent that in Ilongot society we have a most rudimentary stage of political development. There is no tribe. There is no chieftanship. There are no social classes, for the Ilongot have neither aristocracy nor slaves nor what is very common in most Malayan communities, a class of bonded debtors. They have words to designate such classes, a slave being "sina lima" and a debtor "makiotang," but this information was imparted with the repeated statement, "There are none here." I was unable to get any word whatever for a chieftain, although the Ilongot of Neuva Vizcaya spoke of the "nalahaian" or head of the body of kin, but this person seemed to be only the oldest influential relation in the family group. The Ilongot of Patakgao said it was customary to hold a council called "pogon" but it was evident that this gathering was without definite constitution. The feebleness of the political life of the Ilongot can be appreciated by comparing it to the Igorot, the sturdy mountain headhunters in the Cordillera to the west. The Igorot likewise have no conception of the tribe but they do have thoroughly organized towns and town life. They have a detailed social system, based primarily on the possession of wealth; there are slaves, servant and indebted classes, and a carefully developed and adequate body of law covering property,

inheritance, conveyance and contract. Thus the political life of the Igorot, although exceedingly weak on the side of federation or agreement between the independent towns, is centuries of development ahead of the almost institutionless communities of the Ilongot.

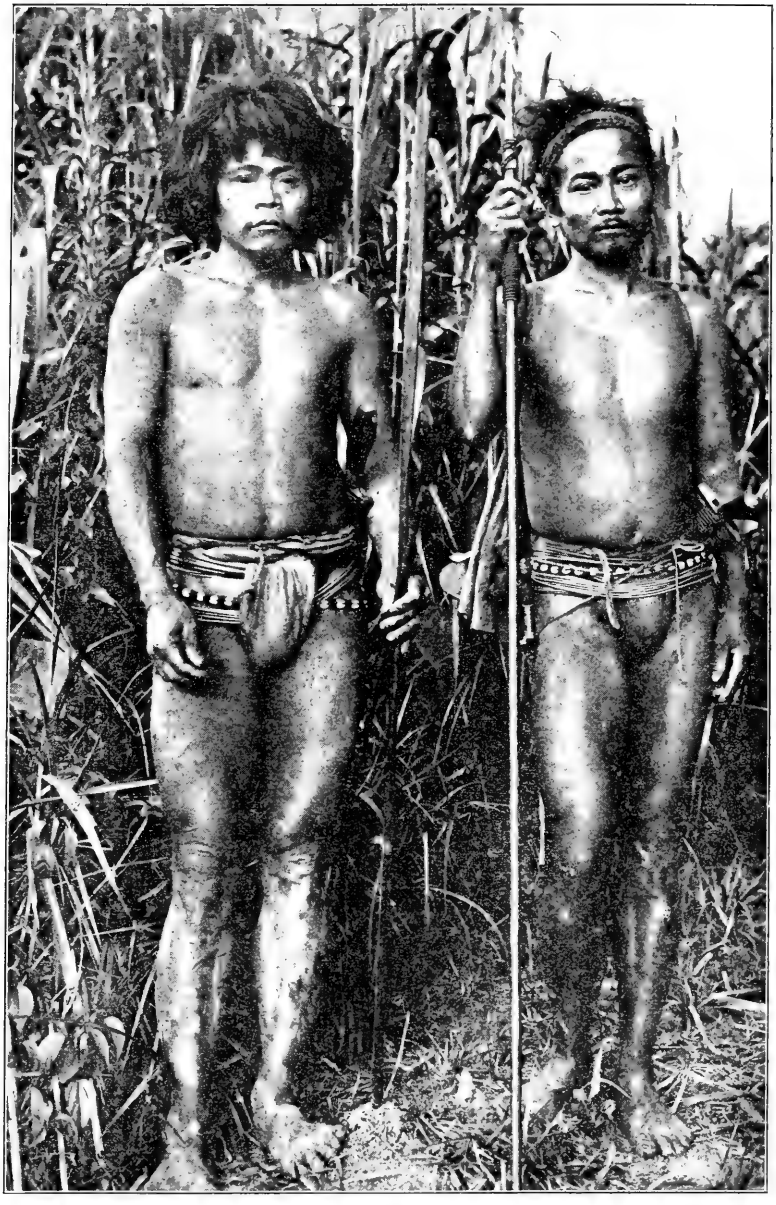
The Ilongot appears to be usually a monogamist and the wife is purchased, or at least a dowry called "piyat" is paid in weapons, utensils, liquor, wire, etc. Her position is not at all that of a bought piece of property, but, like the woman in Malayan society generally, she is the companion and almost the equal in influence and independence of the man.

While the machinery for righting injuries or settling grievances is almost non-existent, the Ilongot has a strong sense of injury and of wrongful acts. He will say with the strongest feeling and disgust that certain actions are "forbidden" (ma kŭl).

I once asked an Ilongot what he would do if a man of a neighboring community, with which relations were peaceful, should come and steal his pig. He thereupon detailed the steps open to him. He might take his weapons and go within hallooing distance of the aggressor's home and demand a double fine or restitution ("baiyad"). If the demand did not avail he would make a solemn warning ("tongtongan") and then, if satisfaction did not follow, there was no recourse but retaliation. I believe, however, that compensation, even for such offenses as murder, is frequently arranged through the anxiety of all members of the family to escape retaliation. Feud, that inevitably arises under such social conditions as these, pursues generation after generation and the obligation that descends to posterity and relations to take vengeance is spoken of as the "debt of life" (utang nu biay).

Apart from the taking of heads as an act of vengeance, murder with the winning of the gruesome trophy is obligatory on the other occasions as well. An Ilongot once said to me "A man may during his life take three, four or even five heads, but he must take *one,* and that before he marries. This head he carries to the relations of his intended wife to prove that his heart and body are strong to defend her." Furthermore, after the palay harvest each year the bundles of unthreshed rice or palay are neatly piled into a stack about a tall stake which is set up in the "kaingin." Then, for some ungodly reason, a human head is very desirable to place on top of this pole. So raids are made, usually on the Christian settlements below. Several questions may be asked regarding these practises, but I can offer nothing by way of answer. To whom is the "debt of life" owed? To the spirit of the dead person? To the customary Malayan spirits of the forest? Only a long acquaintance would enable one to get to the bottom of the motive of such customs as these.

The primitive Malayan is full of beliefs and dreads of the malignant spirits which throng his environment. These are the spirits of forest,



ILONGOT MEN OF PULUDPUD IN THE FORMER SPANISH COMMANDERY OF PRINCIPE.

One carries a bow and arrow, the other a spear with a point which detaches itself from the shaft to which it is attached by a long cord. The dragging shaft impedes the escape of the animal that has been speared until the hunters can come up and dispatch it.

trees, cañons, streams and sea; horribly conceived monsters and ghouls, and furthermore, and omnipresent in the affairs of the living, are the spirits of the dead—the ghosts. The Negrito, on the contrary, seems to be very little disturbed by such beliefs. His elementary religious notions leave him free for the most part from terror by night or by day. Where troubled with conceptions of "anito" or "diwata" it is almost certain that he has been learning at the feet of some demon-worshipping Malayan. Now, the Ilongot appear to have religious ideas that have come from various sources. Those of Nueva Vizcaya, with whom I talked, professed belief in spirits and called them "bĕ tung"; the spirits of the dead were "gi na vá." The Ilongot of Patakgao, curiously, have been affected by Christian nomenclature. The ruling spirit or spirits is "apo sen diot" ("apo" meaning lord or sir and "diot" being a corruption of *Dios*). They had no word for heaven, but mentioned "Impiĕdno" (*Infierno*). They said that when people die "they go to the mountains." They bury the dead near their houses in a coffin of bark (ko ko). They said that there were no "aswang" (malignant monsters believed in by the Christian Filipinos) in their mountains. They stated that prayer is a frequent observance; that they prayed when some one is sick or injured. "When an animal is killed we pray before cutting up the animal," and as stated above prayer is offered before the dangerous ascent of trees. In one house I saw a little bundle of grasses which was put there, following prayer made "at the first time when we are eating the new rice." Prayer is then made that rats may not destroy the harvest or other ill occur to crops.

These notes are too fragmentary to give any definite idea of what the religion of the Ilongot may be, but two other things observed had religious significance. When our party reached the vicinity of the community at Patakgao, we encountered in the bed of the cañon we were following a curious contrivance placed over the running water. Two stakes had been set up, and attached horizontally was a branch twelve feet long, five or six feet from the ground. A chicken had been sacrificed here and its blood had been daubed along this pole in at least eighteen different stains. Feathers had been tied to the ends of the upright poles and midway between them a curiously whittled stick of shavings was tied perpendicularly and the giblets and head of the fowl stuck upon it. Our guide, who was a Christian native from a small barrio which has some relations with this community, pronounced this contrivance to be a warning against further approach, in fact a "dead line." But later, Bŭliŭd, one of the important men of Patakgao, insisted that it was an offering made for the cure of their wounds received a few days before in a fight with hostile Ilongot.

In the houses of the Ilongot at Bayyait were many curiously whittled sticks suspended from the rafters. Some of these were of ir-

regular shape like a ray of lightning; many were bunches of shavings, singularly suggestive of the prayer sticks of the Ainu.

The language of the Ilongot is predominantly Malayan. It contains a large bulk of words identical or related to the surrounding Malayan tongues. There are a few Sanskrit or Indian words, "pagi" (palay, "paddy," the unhulled rice) and "pana" for arrow, both words widely diffused in Malaysia. But besides, there is a doubtful element which does not seem to be Malayan; at least no similar words or roots occur in any of the other vocabularies of primitive peoples of northern Luzon collected by me. The Ilongot continually makes use of a short ŭ, which sometimes becomes the German sound ü as in "buh dŭk," a flower. These sounds can not be imitated by the Christian people in contact with them. This is a condition similar to what we find in Negrito speech, where, with a preponderance of terms occurring in Malayan languages, are often a number of totally distinct and usually eccentric words and sounds.

Finally, it is manifest that the Ilongot are a problem to the government of the islands. What is to be done with such people as these? They can not be allowed to continue, as they have done, to harass and murder the peaceful population of Nueva Ecija, northern Pangasinan and Nueva Vizcaya. Some means must be found to restrain them. Humanity does not permit their extermination. Steps are now being taken to do something to get them in hand. The exploring parties above referred to have opened the way. The communities organized under teachers of the Bureau of Education seem to promise something as well. Last fall when I left the islands search was being made for the right sort of an American teacher to put in charge of school interests at Baler, with jurisdiction over the Ilongot villages appurtenant thereto. The people of Patakgao since my visit have accepted an invitation, then made, to send their young men and boys to the barrio of San Juan, a village in the mountains back of Pantabangan, where a school is conducted and where several of these youth are now living in charge of a native man in whom the Ilongot have confidence. The Bureau of Education meets the slight expenses of this educational experiment. This work of social development, here as in a thousand similar places in the Philippines, will be best done by the American teacher, but the task is inviting only to the man in whom the spirit of youth and adventure and fascination with human problems runs strong.

Mr. Murphy's last report concluded, "I believe the schools can do these people a great amount of good and solve the government's worst problems. The work, however, is dangerous, as the man who undertakes it has no protection but his own diplomacy in handling the people. If trouble comes it will be from the young bucks, desirous of gaining a reputation."

KANT AND EVOLUTION

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I

IT has come to be one of the generally accepted legends of the history of science that the author of the "Kritik der reinen Vernunft" was also a pioneer of evolutionism. In the anthropological essays of the Koenigsberger, for example—we are assured by the writer of a German treatise on Kant's philosophy of nature[1]—"we already find the most essential conceptions of the modern theory of descent indicated, at least in germ—and, indeed, in a way that marks Kant out as a direct precursor of Darwin." The same expositor says:

> Throughout these writings the idea of evolution plays everywhere the same rôle as in contemporary science. . . . The series of organisms is for Kant in a constant flux, in which the seemingly so stable differentiæ of genera and species have in reality only a relative and subsidiary significance.

And in a famous passage of the "Kritik der Urteilskraft," says another writer, "the present-day doctrine of descent is clearly expressed in its fundamental features."[2] Haeckel, who is in the main followed by Osborn, goes even farther in his ascription of Darwinian and "monistic" ideas to Kant's earlier works, though he thinks that in later life Kant fell from grace. Haeckel says:[3]

> In various works of Kant, especially in those written in his earlier years (between 1755 and 1775) are scattered a number of very important passages which would justify our placing him by the side of Lamarck and Goethe as the principal and most interesting of Darwin's precursors. . . . He maintains the derivation of the various organisms from common primary forms, . . . and was the first to discover the principle of the "struggle for existence" and the theory of selection. For these reasons we should unconditionally have to assign a place of honor in the history of the theory of development to our mighty Koenigsberg philosopher, were it not that, unfortunately, these remarkable monistic ideas of young Kant were at a subsequent period wholly suppressed by the overwhelming influence of the dualistic, Christian conception of the universe.

[1] Drews, "Kants Naturphilosophie," 1894, pp. 44, 48.

[2] Schultze, "Kant and Darwin," 1875, p. 217. Schultze's monograph, perhaps the earliest, and hitherto the most comprehensive, on the subject, seems to be responsible for much of the error into which subsequent writers have fallen. It consists, indeed, chiefly of reprints of the greater part of each of the writings in which Kant approaches the topic in question; but it is accompanied by a commentary and notes in which Schultze gives a highly misleading impression of Kant's actual utterances.

[3] "History of Creation," Lankester's translation, 1892, p. 103. Cf. Osborn, "From the Greeks to Darwin," 1894, pp. 98–9.

Yet even at the last, though Kant's nature-philosophy became less "monistic," Haeckel finds his biology scarcely less evolutionistic. In the "Kritik of Judgment" Kant, according to Haeckel, still "asserts the necessity of a genealogical conception of the series of organisms, if we at all wish to understand it scientifically." In the supposition of a marked "change of view from Kant's earlier to his later years" with respect to the applicability of the principles of natural causation in the realm of the organic, Osborn concurs with Haeckel. Finally, the writer of the historical article in the volume issued by English biologists in commemoration of the Darwin centenary, declares that Kant may be "best regarded as the culmination of the evolutionist philosophers" of the eighteenth century.[4]

These accounts of Kant's historic position in relation to transformism are interesting but scarcely accurate. Kant wrote for the most part at a time when the conception of organic evolution had been made familiar by two of the most celebrated and most influential men of science of the period, Maupertuis and Buffon. He was himself throughout his life especially interested in two distinct scientific problems, both of which made a consideration of the hypothesis of the mutability of species inevitable, and an acceptance of it natural. He accordingly more than once refers to it. But on no occasion does he unequivocally express belief in it; and on several occasions, some of them in his earlier, some in his "critical," period, he vehemently rejects it. The utmost that can be said for him as a biological evolutionist is that, late in life, he once timidly coquetted with the hypothesis—speaking in a vaguely favorable way of it in the text, and then in a definitely unfavorable way in a footnote; and that at the very end of the century it occurred to him to wonder whether the higher apes may not yet acquire a gait, speech and intellectual powers similar to man's. On the other hand, it is not true that any such change of view as Haeckel and Osborn have described took place in Kant's mind with respect to the possibility of explaining the origin of organisms or the processes of organic life in mechanistic terms. Kant at no time affirmed any such possibility; and he repeatedly gave expression to an emphatic denial of it, in his earlier as well as his later utterances. Upon both this question and the question of descent, so far as any change of emphasis is distinguishable at all in Kant's successive opinions, it is a change in quite the contrary direction to that which Haeckel indicates.

These statements, in view of the wide prevalence of contrary be-

[4] J. Arthur Thomson in "Darwin and Modern Science," p. 6. Similar expressions from a number of other writers might be cited. I have myself, before coming to close quarters with the subject, fallen into the error of classifying Kant among the early evolutionists (*Popular Science Monthly*, November, 1909, p. 513). Yet for the past twenty years a substantially correct account of the matter has been accessible, in a brief article by J. Brock, *Biologisches Centralblatt*, Bd. VIII., 1888–9, pp. 641–8.

liefs, can be properly substantiated only by an examination of all the more important writings of Kant (in their approximate chronological order) which bear upon the topic in question. Such an examination will at the same time show that the misapprehensions of his position which have arisen are by no means unnatural results of taking certain of his expressions apart from their contexts and in disregard of the meanings which he was accustomed to give to certain terms.

1. *The "Universal Natural History and Theory of the Heavens."* —That Kant in his earliest important writing, the "Allgemeine Naturgeschichte und Theorie des Himmels," 1755, gave an outline sketch of cosmic evolution which anticipated the nebular hypothesis of Laplace, is one of the things that every schoolboy knows. Like most such things, it is not exactly true. Kant's cosmological speculations were, as we shall see, in scope and in method and in their most essential principles, extremely dissimilar to the nebular hypothesis. Kant's enterprise was far more ambitious than that of the French astronomer; he was concerned with the evolution of a universe out of primeval chaos, not merely with the formation of a planetary system out of a whirling nebula. As a detail of his scheme, it is true, he sought also to explain how planets are formed, and how their orbital revolution is to be accounted for; but his version of their origin is such as to justify us in classifying him with a school of cosmogonists of much later date than Laplace, who are strongly opposed to Laplace's hypothesis. Kant's treatise in its entirety will, I think, hardly be found to merit the extravagant eulogies which it has won—at any rate, upon the score of originality or of historic influence and importance. On these two points, at least, we shall find it necessary to agree with a German writer who has recently dealt with the book. Gerland says:[5]

> An epoch-making or a foundation-laying piece of work it has not been, either for the eighteenth century or the nineteenth. The assertion of Kuno Fischer and others that Kant became by virtue of it "the founder of modern cosmogony," is a false and unhistorical exaggeration. It would be justified only if Kant's book had been the first in its field, and if our present cosmogony had developed in direct dependence upon it; but nothing is farther from being the case—in spite of a number of points of coincidence between Kant's conceptions and contemporary ones.

Gerland adds the opinion that Kant's book remained unknown in its own time, "not because of the bankruptcy of the publisher [which for many years interfered materially with its sale], nor through the fault of the people or of the men of science of Kant's day; it remained unknown through its own faults."

Even at the risk of a somewhat lengthy digression from the question of Kant's place in the history of biology—with which this paper is primarily concerned—I think it worth while to try to make clear the

[5] *Kantstudien*, 1905, 417 f.

historic relations of his cosmic evolutionism to that of both his predecessors and his successors. The matter has never, it seems to me, been quite justly set forth. It will at the same time be pertinent to observe the position with respect to organic evolution in which Kant's cosmic evolutionism left him.

The great, outstanding scientific event of the early eighteenth century was the triumph of the Newtonian system of celestial mechanics, based on the principle of gravitation in accordance with the law of inverse squares, over the Cartesian system of vortices, which had dominated seventeenth century physics and astronomy. Now Descartes, a more versatile and ingenious and a bolder mind than Newton, had himself elaborated his physical theories into a comprehensive philosophy of nature and a fairly detailed cosmology and cosmogony. But Newton had inscribed upon the last page of the "Principia" the maxim *hypotheses non fingo;* moved both by scientific caution and by religious piety, he had deliberately refrained from putting forward either a general system of the heavens outside of the solar system or a mechanistic explanation of the genesis of the revolutional and rotatory motions and the arrangement of the planets of our system. "All these regular motions," declared the concluding scholium of the great treatise, "do not have their origin from mechanical causes. . . . This most elegant structure of sun and planets and comets could not have arisen apart from the wisdom and the rule of an intelligent and powerful being." And Newton sums up with, as it were, a "let us hear the conclusion of the whole matter," by which he would define the whole duty of explanatory astronomy: *Satis est quod gravitas revera existat, et agat secundum leges a nobis expositas, et ad corporum cœlestium et maris nostri motus omnes sufficiat.* "It is enough that gravity really exists, and that it acts according to the laws which we have set forth, and that it suffices for all the motions of the heavenly bodies and of our sea."

But to many of those who devoted themselves with enthusiasm to the propagation of Newton's positive doctrines, the self-denying ordinance with which he had ended was far from agreeable. That that ordinance should be transgressed by more intrepid and more architectonic minds was inevitable. We find, therefore, in the early eighteenth century a number of writers who busied themselves with the further elaboration of the Newtonian "natural philosophy," with the application of Newton's laws to problems the master himself had refused to discuss. In these attempts the writers in question were in part merely doing over again upon Newtonian principles what had already been done upon Cartesian principles (now discovered to be erroneous) by Descartes himself. Among the German enthusiasts for the completion of Newton's system and the extension of it into a general cosmology, one of the most zealous and most active was the young Kant. His early preoccupation with these matters was doubtless due to the influence of

one of his university teachers, Knutzen, professor of logic and metaphysics at Koenigsberg, who was at once an ardent Pietist, an ardent Wolffian, and an ardent Newtonian. All of the earliest three considerable writings[6] of Kant may be said to be chiefly attempts to give new applications to Newton's principles, or to supply his omissions, or to do both at once. Of these three, the treatise with which we are here concerned, the "Allgemeine Naturgeschichte" of 1755, was an endeavor to fill up two of the most obvious gaps (from the cosmical system-maker's point of view) which the author of the "Principia" had left. It required no great originality and no stroke of genius on Kant's part to recognize these gaps and to devise the general outlines of the hypotheses by which he tried to fill them. The problems, and in one of the two cases at least, the proposed solution even in most of its details, were present in the scientific atmosphere of the period as epidemic infections.

The first of these gaps, and the one less pertinent to our present topic, lay in Newton's failure to suggest even a conjectural hypothesis concerning the systematic arrangement of the heavenly bodies beyond the boundaries of our system. To three of his disciples at almost the same time[7]—but to the two others at an earlier date than to Kant—it occurred as a "probable," though perhaps not strictly verifiable, supposition that our group of planets with its central sun is only a part of an analogous but larger concentric system of revolving bodies, or of similar groups of bodies, constituting the Milky Way; and that this in turn is but part of a single, universal system, all the members of which are similarly arranged with respect to one another, and revolve about a body at the center of gravitation of the entire universe in accordance with Newton's laws. The hypothesis had, of course, an attractive combination of grandiosity and simplicity; and it was natural enough to inquire whether or not it were true. But it was, I suppose, essentially incapable of any serious testing by any data then in the possession of astronomers. It is apparently only within the past five years that some light has been thrown upon the problem of a possible "systematic arrangement" of the fixed stars;[8] and the arrangement which recent re-

[6] "On the True Mode of Estimating *Vis Viva*," 1747; "Universal Natural History and Theory of the Heavens," 1755; "Physical Monadology," 1756.

[7] To Thomas Wright, of Durham, before 1750; to Lambert, 1749; and to Kant. Wright's "Original Theory or New Hypothesis of the Universe, founded upon the Laws of Nature and solving by Mathematical Principles the General Phenomena of the Visible Creation," London, 1750, was known to Kant through a summary in the Hamburg *Freie Urteile*, 1751, and is referred to by him in the "Allgemeine Naturgeschichte." Lambert's "Kosmologische Briefe" were not published until 1761, but were planned and partly written in 1749, as Lambert declares in a letter to Kant, November 13, 1765.

[8] See the article of Eddington on "Star-Streams," in *Scientia*, VIII., 1910, p. 40.

search seems to disclose is not in the least such as Kant imagined. Kant himself is at pains to notify his readers, in his preface, that his reasonings on the subject do not pretend to "extreme geometrical precision and mathematical infallibility." Yet it can not be denied that in the body of the work Kant presents his hypothesis as if it could be, and had been, established with rather more than a high degree of probability.

> If all the worlds and systems of worlds acknowledge the same mode of origination; if attraction is unlimited and universal, while the repulsion of the elements is likewise everywhere active; if in the infinite both great and small are small alike;—then must not all these worlds have received the same relative constitution and systematic arrangement as that which the bodies of our own solar system exhibit on a small scale? . . . If, again, these are viewed as members in the great chain of Universal Nature, then there is still the same reason to think of them, in turn, as existing in the same reciprocal relations and interconnections—which, in virtue of the primary structural law ruling all nature, make of them a new and greater system, ruled by a body of incomparably mightier attractive force at the center of their systematically ordered positions.

Thus the whole universe will compose a single system held together "by the connecting power of gravity and of centrifugal force." For if it were made up, instead, of a multitude of irregularly scattered systems, of groups of stars not in revolution about a central body, Kant argues that, in order to prevent the reciprocal attractions of these systems from "destroying them" there would be requisite

> such an exactly measured disposition of them at distances proportionate to the attractions, that even the slightest displacement of them would bring about the ruin of the universe. . . . But a world-order that could not maintain itself without a miracle would lack that character of stability which is the distinguishing mark of the designs of God. It is therefore far more consistent with those designs to make the whole creation a single system in which all the worlds and systems of worlds that fill the whole of infinite space stand related to a single center.[9]

It will, I suppose, hardly be maintained, even by Kant's most devout admirers, that in his argumentation in behalf of his "theory of the heavens" he displays a high degree of scientific caution or a very nice sense for the distinction between the considerations that are, and those that are not, admissible in scientific inference.

The second undeveloped problem which Newton had left to tempt the ingenuity of his disciples was the problem of cosmogony. In attacking this upon Newtonian principles Kant showed no greater originality; he had many forerunners in the enterprise, in the preceding half century, and the enterprise itself was an obvious one. For the celestial mechanics of Descartes had found one of its earliest and most striking applications in a cosmogony. Descartes's first book, his "Traité du Monde," written in 1633, had been chiefly a treatise on cosmic evolu-

[9] "Allgemeine Naturgeschichte," 1798 ed., pp. 77–85; tr. in Hastie, "Kant's Cosmogony," p. 136 f.

tion based upon mechanical principles. That book had, it is true, been suppressed by its author, who, upon hearing of the treatment received by Galileo, had preferred to take no chances for the prize of martyrdom. But he had in Pt. V. of the "Discourse on Method" recapitulated briefly the outline of his scheme of world-evolution; in the "Principia" he had given some of the details of it; and the treatise itself, or a revision of the principal part of it, had been published after his death by his friend Clerselier, in 1664. While refraining, with what might seem sufficiently unimpeachable orthodoxy, from maintaining that the present constitution of the world actually had been evolved, rather than created ready made, Descartes also insisted that it was perfectly conceivable that it should have been evolved. He declared himself ready, if given as a starting point even "a chaos more confused and involved than any poet ever could describe," to deduce, with the aid only of the ordinary laws of the motion of matter, the necessity of the gradual formation out of that primeval chaos of a world having the characters and the contents of the world as man now finds it. He endeavored to show how matter "must needs, in consequence of those laws, have arranged itself in a certain way which made it similar to our heavens; how some of its parts would necessarily become an earth, and some planets and comets, and others a sun and fixed stars. And . . . coming to speak more particularly of the earth," he set forth, "how the mountains, seas, fountains and rivers can naturally have been formed in it, and the metals have come to exist in the mines, and the plants to grow in the fields, and, in general, how all the bodies which are called mixed or composite could have been generated."

Now, it is certain that Kant had the cosmogony of Descartes in mind in writing the "Universal Natural History," for he refers to it in his preface. Defending himself against the imputation of materialism and irreligion, Kant writes:

> I shall not be refused the justice which fair judges have always rendered to Descartes, with respect to his attempt to explain the formation of the world from purely mechanical laws. I therefore cite the remark upon this subject of the authors of the "Universal History": "We can not but think the essay of the philosopher who endeavored to account for the formation of the world in a certain time from rude matter, from the sole continuation of a motion once impressed, and reduced to a few simple and general laws; or of others who have since attempted the same, with more applause, from the original properties of matter, with which it was endued at the creation, is so far from being criminal or injurious to God, as some have imagined, that it is rather giving a more sublime idea of his infinite wisdom." [10]

Thus Kant, anticipating vituperation from the orthodox on account of his cosmic evolutionism, pleads not only the Cartesian precedent, but

[10] The version of the citation here given is that of the original English, as in Hastie's "Kant's Cosmogony."

also the favorable views already taken of that precedent by writers of recognized respectability.

Moreover, as the passage just cited indicates, Descartes was not the only, though he was the most eminent, predecessor of Kant to set an example of an undertaking similar to that upon which Kant was entering. Hypotheses about the origin of the world or of our planet may be said to have been especially in fashion during the late seventeenth and early eighteenth century. In the words of Cuvier,[11]

> The end of the seventeenth century saw the birth of a new science, which took in its infancy the high-sounding name of "Theory of the Earth." Starting from a small number of facts badly observed, connecting them by fantastic suppositions, it professed to go back to the origin of worlds, to, as it were, play with them, and to create their history.

The "Theoria Telluris Sacra," 1681, 1689, and the "Archæologiæ Philosophicæ," 1692, of Thomas Burnet, and the "New Theory of the Earth," 1696, of William Whiston—successor to Newton's professorship at Cambridge, effective popularizer of the Newtonian doctrines, and the supposed original of Goldsmith's "Dr. Primrose"—were based upon an incongruous mixture of scientific and scriptural considerations; but they at least made cosmogony a topic of general interest. As much, if little more, can be said of Woodward's "Essay toward a Natural History of the Earth and Terrestrial Bodies," 1695. But in 1734 there was published at Leipsic a treatise which resembled Laplace's theory much more nearly than did Kant's. The "Principia rerum naturalium" of Swedenborg—already celebrated as a geologist and metallurgist, not yet celebrated as a mystic and religious reformer—enunciated the following theses:[12]

> That the sun is the center of a vortex; that it rotates upon its axis; that the solar matter concentrated itself into a belt or zone or ring at the equator, or rather at the ecliptic; that by the attenuation of the ring it became disrupted; that upon the disruption, parts of the matter collected into globes; . . . that the globes of solar matter were projected into space; . . . that in proportion as the igneous matter thus projected receded from the sun it gradually experienced refrigeration and consequent condensation; that hence followed the formation of the elements of ether, air, aqueous vapor, etc., until the planets finally reached their present orbit; that during this period the earth experienced a succession of geological changes which originated all the varieties in the mineral kingdom, and laid, as it were, the basis of the vegetable and afterwards of the animal kingdoms.

The idea of planetary evolution was thus anything but a novelty in 1755. What is more, the decade immediately preceding the completion of Kant's "Allgemeine Naturgeschichte" may be said to have been especially distinguished by the prominence with which, during it, questions of cosmogony were brought to the attention of the learned world.

[11] "Eloge de Werner," cited in Packard's "Lamarck," p. 92.

[12] I borrow the summary of Clissold, from his introduction to the English translation of Swedenborg's "Principia," 1846.

The work from which Kant quoted a justification of Descartes's enterprise—and, by implication, of his own—the "Universal History" (1736–65) appeared in an (incomplete) German translation in 1744. This huge historical compilation, one of the great publishing enterprises of the time, contained an introduction of (in the German edition) over one hundred pages devoted to the subject of cosmogony, giving the theories of the Greek philosophers, of Descartes, Burnet, Whiston and other moderns, and a new hypothesis of the author's own. In 1749 the first volume of a still more celebrated, and scarcely less voluminous, publication—Buffon's "Histoire Naturelle"—saw the light. This volume was chiefly devoted to a "history and theory of the earth," with a chapter on the formation of planets which contained ideas more closely related than those of Kant to the nebular hypothesis. Buffon remarked upon the peculiar uniformities of the solar system which seemed to call for a mechanical explanation, but which gravitation alone did not account for, viz., the revolution of all the planets in the same direction, approximately in the same plane, and in nearly circular orbits. Buffon's own explanation of these phenomena in his "Théorie de la Terre" of 1749 is given in the following passages:

> This uniformity of position and direction in the movement of the planets necessarily presupposes some common factor in their original movement of impulsion, and makes us suspect that it has been communicated to them by one and the same cause. . . . This impulsive force was certainly imparted to the stars in general by the hand of God when he set the universe in motion. But since, in physical science, we ought to abstain so far as possible from having recourse to causes outside of nature, it seems to me that in the solar system we can account for this impelling force in a sufficiently probable manner and in accordance with the principles of mechanics. . . . May it not with some probability be imagined that a comet falling upon the surface of the sun may have separated from that body certain parts, to which it has communicated a movement of impulsion in a common direction? . . . The planets would thus have formerly belonged to the sun, and would have been detached from it by an impelling force, common to all alike, which they still retain.[13]

Buffon was the only one[14] of his precursors (of the post-Newtonian period) known to Laplace. He made this passage of the "Histoire Naturelle" the starting point of his own earliest exposition of his nebular hypothesis, in the concluding chapter of the "Système du Monde." The hypothesis of Buffon, he remarked, accounted for most of the non-gravitational peculiarities of planetary motion that require to be accounted for; but since there remained certain other such phenomena which Buffon's supposition could not explain, a new hypothesis must be devised.

Finally, in the same year, 1749, a generation after its famous

[13] "Histoire Naturelle," first ed., I., pp. 131–133. Kant had read Buffon before writing his own cosmogony; see "Universal Natural History," Pt. II., ch. 2.

[14] Cf. "Système du Monde," first ed., 1796, II., p. 298.

author's death, the "Protogæa" of Leibniz was published. In this Leibniz contended, on grounds now familiar enough, that the earth must have originally been in a fluid and intensely heated state; that through the cooling of the surface a solid crust was formed and the viscous fiery substance of the globe concentrated in the interior; that the present earth-structure is due to the successive action in the past of fire (fusion) and water (sedimentation); and that the existence of fossils testifies to the extinction of once flourishing species of animals, in consequence of modifications of the earth's surface due to one or the other of these agencies.

For comparison with the hypotheses of his precursors and successors, Kant's own scheme of cosmogony must now be indicated in its more essential features. He assumes for a starting point a "state of nature which is the very simplest that could follow upon nonentity," namely, a chaos in which all the matter in the universe was scattered throughout infinite space. It somehow "filled" the whole of that space, and yet its component particles were infinitely more diffused than now; Kant expressly declares that space was once "full," and is now "empty," except for the actual celestial bodies. The original particles were not all alike; they differed in "specific density and force of attraction." Consequently, when the universe is once permitted to begin active business, "the scattered elements of the denser sort, by virtue of their attraction, gather together out of the space surrounding them all the matter of less specific gravity; these elements in turn, with the material which has united with them, collect in points where the particles of a yet denser kind are found"; and so on.

> If we follow in imagination this process by which nature fashions itself into form throughout the whole extent of chaos, we easily perceive that the sole result of this process would consist finally in the agglomeration of divers masses which, when their formation was complete, would be forever at rest and unmoved.

Fortunately, nature has other forces at her command; besides gravitation, there is also operative a force of repulsion, which shows itself "especially when matter is decomposed into fine particles." By this force the elements, "as they fall towards the attracting body are deflected by one another and have their perpendicular fall converted into a movement of revolution." Having indicated the two general working principles of his cosmical mechanics, Kant now judiciously leaves the problem of the genesis of a universe, and turns somewhat abruptly to the simpler problem of the formation of our solar system, from the solution of which "we shall be able by analogy to infer a similar mode of origination in the case of the larger world-systems."

The lesser process, as Kant conceives it, may be said to fall into four stages: (1) *The formation of the nucleus of a sun.* There is formed at the point of maximum attraction of a given region of space, "a body which, so to say, grows from an infinitely small germ, at first

slowly (through chemical attraction), then more rapidly (through the so-called Newtonian attraction), and always in proportion as its mass increases, draws the surrounding parts more and more strongly to unite with itself." This central body is not strictly to be called a sun at the outset, for it is not yet "in a flaming state"; this it only gradually becomes as, in the course of the subsequent processes of readjustment, "the lighter and more volatile portions of the primitive matter," failing to maintain a movement of periodic revolution, drop into the center of attraction. (2) *The formation of a whirl of unaggregated particles moving round this central body in circular but separate and intersecting orbits.*

When the mass of the central body has grown to such a point that the velocity with which it draws particles to itself from great distances is, by the weak degrees of repulsion with which the particles impede one another, deflected into lateral motions which, by virtue of centrifugal force, encompass the central body in an orbit—then there are produced great whirls of particles, each of which, by reason of the composition of the gravitational force and the force making for deflection sideways, describes a curved line. These orbits all intersect one another . . . and are in conflict with one another.

(3) *The transformation of this disordered whirl of particles into a ring or disc of particles moving in free, parallel, circular orbits round the central body.* The conflicting movements of the preceding stage come eventually to such an adjustment that they interfere with one another as little as possible. This happens in two ways:

First, by the particles limiting each others' movements till they all advance in one direction; second, by their limiting their vertical movements towards the center of attraction till, all moving horizontally in parallel circles round the sun as their center, they no longer intersect one another's paths, and, by the equalization of the centrifugal and centripetal forces, they maintain themselves constantly in free circular orbits. In this state, when all the particles are moving in one direction and in parallel circles, the conflict and collision of the elementary bodies is annulled, and all things are then in the condition of least reciprocal interference.

Further, "in acordance with the laws of centrifugal motion, all these revolutions must intersect the center of attraction with the plane of their orbits"; and for bodies moving in a common direction round a common axis, there is only one such plane. Therefore, the revolving particles gather about "that circle which passes through the rotation of the axis in the center of the common attraction," and the system assumes (though there are as yet no planets) that discoid form characteristic of our present planetary system. (4) *The gradual formation, within this ring, of planets, through the attractions subsisting between the separate particles composing it.* Kant has hitherto treated attraction chiefly as operative between the central mass and the particles; between particle and particle the relation has been one of repulsion. But at this point, "the attraction of the elementary bodies for one another begins to produce its effect, and thereby gives the start to new

formations which are the seeds of the future planets. For the particles, as they move round the sun in parallel circles and at not too great a difference of distance from the sun, are, by the equality of their parallel motion, almost at rest with respect to one another, and thus the attraction of those particles which are of a higher specific attraction immediately produces an important effect, namely, the collection of those nearest one another so as to form a body which, in proportion to the growth of its mass, extends its attraction farther and draws elements from a wide region to unite with it in its further formation."

It must be left to mathematicians and astronomers to assess the precise merits of these speculations in comparison with those of Kant's predecessors and successors in the same undertaking. But as to the historic affinities of Kant's hypothesis the facts seem so clear that even a layman may pronounce upon them. The Kantian scheme is as different from Laplace's as any post-Newtonian cosmogony could well be. For it does not start with a gaseous, rotating, heated nebula; it does not explain the direction of revolution and rotation of the planets as derived from the rotation of a mass formerly cohering with that now constituting the sun; it does not regard the planets as having ever formed part of any such mass. It is well-known that the rings of Saturn suggested the most characteristic feature of Laplace's theory. Kant has a chapter explaining these rings much as Laplace does; but he expressly insists that "the ring which surrounds Saturn was *not* acquired in the general way, nor has been produced by the universal laws of formation which have ruled the whole system of the planets." On the other hand, it is not quite exact to identify (as does Hastie[15]) Kant's system of planetary evolution with the meteoritic hypothesis of Lockyer and G. H. Darwin. So far as I understand these matters, Kant's cosmogony most nearly resembles an extremely recent doctrine upon the subject—the planetesimal hypothesis of Chamberlin and Salisbury. In the words of those authors:

> Under the typical form of that hypothesis it is assumed that the parent nebula of the solar system is formed of innumerable small bodies, planetesimals, revolving about a central gaseous mass much as the planets do to-day. The evolution of the system consisted in the aggregation of these innumerable small bodies into much fewer large ones. . . . The hypothesis, therefore, postulates no fundamental change in the system of dynamics after the nebula was once formed, but only an assemblage of the scattered material. The state of dispersion of the material at the outset, as now, was maintained by *orbital revolution*, or, more closely speaking, by the centrifugal acceleration arising from revolution.[16]

[15] "Kant's Cosmogony," 1900, p. lxxxiv. At this date, of course, the planetesimal type of hypothesis had hardly been differentiated from the meteoritic.

[16] Chamberlin and Salisbury, "Geology," 1906, II., p. 38. The authors of this theory have failed to recognize in Kant an early prophet of their own doctrine, and have referred to him, in the conventional manner, as having held a hypothesis "somewhat similar" to Laplace's (*op. cit.*, p. 4).

There are, of course, very material differences between the contemporary and the Kantian form of the hypothesis; notably, our contemporary geologists ascribe "the gathering of the planetesimals to the nuclei, to form the planets, essentially to conjunctions in the course of their orbital motions, not," as does Kant, "to simple gravitation, except as gravitation was the fundamental cause of the orbital motions." But in the two cardinal points Kant's *is* a planetesimal theory: (1) it conceives the planets to have grown by gradual accretions from very small nuclei, not to have been condensed from large masses "abandoned" or thrown off by a rotating, gaseous sphere; (2) it also conceives these nuclei to have been in regular orbital revolution about a central body *before* the formation of planets as such. The first trait distinguishes both the planetesimal and the meteoritic hypotheses from the general type of theory to which the conjectures of Swedenborg, Buffon and Laplace alike belong; the second is the specific mark differentiating the planetesimal hypothesis in turn from the meteoritic. "If," in the words of Chamberlin and Salisbury, "the meteorites could be supposed to come together so as to revolve in harmonious orbits about a common center, on a planetary basis, the assemblage might be perpetuated, but this takes the case out of the typical meteoritic class, and carries it over to the planetesimal." It is precisely this that we find exemplified in the third stage of the Kantian cosmogony.

Whether, in view of the state of knowledge in his time, Kant had any good reasons for preferring his theory to those of the other type which Swedenborg and Buffon had already put forward, I shall not venture to discuss. In any case, the features of Kant's cosmogony which establish its kinship with the planetesimal hypothesis are closely connected with one of the most elusive and most questionable details of his system of dynamics—namely, his "force of repulsion." It is this and this alone which (to his mind) explains why particles, as they fall towards the center of attraction, are "deflected sideways" and thus have their rectilinear motion converted into movement of revolution. It is likewise the establishment of an equilibrium between repulsive and attractive forces that, as he conceives, gives shape and determinate limits of size, not only to planets, but to all coherent and individuated masses of matter.[17] This notion of a *Zurückstossungskraft,* which he took over from Newton, but the use of which to explain revolutional motion Newton would never have sanctioned, was a favorite one with Kant from the beginning of his career to the end; he reverts to it so late as 1786, in his "Metaphysical Foundations of Natural Science." It is in the "Physical Monadology," 1756, that we get the most definite account of it. We there learn the quantitative formula for this force, when acting between any two bodies; while attraction decreases in proportion to the square of the distance, repulsion decreases

[17] "Monadologia Physica," X.

in proportion to the cube.[18] Kant seeks, by reasonings both obscure and peculiar, to establish an *a priori* necessity that these two forces—emanating from identical points and perfectly analogous save in the direction of the motion of the external particles they affect—should yet differ in the ratio in which their potency decreases with distance. But in the "Universal Natural History" the disciple of Newton bases no calculations, such as could be compared with the actual positions and densities of the heavenly bodies, upon this quantitative formula—of which, possibly, he had not yet bethought himself. In fact, in his cosmogony he wholly fails to indicate even an approximate law of the action of repulsive force. When the plot of the world-story threatens to come to a standstill or to issue in a hopeless entanglement, "repulsion" like a *deus ex machina* appears upon the scene to set things right and ensure a happy ending. Precisely the same particles, under what (so far as one can judge from Kant's language) might be similar physical conditions, and at approximately equal distances, figure now as attracting, now as repelling, one another, as the exigencies of the hypothesis require. That a theorist who improvised laws of dynamics in so easy-going a manner proves to have anticipated a very recent conception of planetary evolution, must, I think, be regarded rather as evidence of good luck than of scientific good management.

What, now, was, for Kant himself, the bearing of his doctrine of cosmic evolution upon biology? Descartes, holding the theory of animal automatism, had undoubtedly regarded the formation of organisms as part of that mechanical process of the redistribution of matter which also explained the formation of suns and planets. Such a view was not necessarily equivalent to a belief in the transformation of species. There is no necessary logical connection (though there is a natural affinity) between a mechanistic physiology and transformism—any more than between a vitalistic physiology and the doctrine of the fixity of species. Thus the question concerning the relation of cosmic evolutionism to biology is merely the genetic form of the issue of vitalism *versus* mechanism; in it the problems of the theory of descent need not be directly implicated. Upon this question a view current in Kant's time was that the gradual genesis of inorganic things might well be ex-

[18] Kant's conception of "repulsive force" is used by him in the "Physical Monadology" primarily to explain the impenetrability of bodies (for which he supposes that a special force must be posited). But it is not identical with impenetrability; it is explicitly represented by him as a force acting *in distans*. In the "Universal Natural History" it is rather to the phenomena of solutions and the expansion of gases that Kant points as empirical evidence of the existence of such a force. Newton ("Optics," Bk. III., Q. 31) had made a like inference from the same phenomena; but he did not write, as Kant did, seventeen years after D. Bernouilli had propounded the kinetic theory of gases. And it is impossible to imagine Newton deducing a cosmogony by the use of a conception so loose and quantitatively indefinite as is Kant's conception of repulsive force in the "Universal Natural History."

plained from mechanical principles, but that no such explanation could be given of the origin and the characters of living beings. Such was the position taken by the author of the introduction to the "Universal History," whom we have already seen Kant quoting.

> The manner of the original formation of plants and animals, in which the wisdom of the Creator principally appears, has never been accounted for by any philosopher with any tolerable success; matter and the laws of motion having nothing at all to do in these things, whatever they have in the inanimate parts of the world.[19]

And this was substantially the attitude which Kant adopted, in the one passage of the "Allgemeine Naturgeschichte" in which he definitely discusses the matter.

> We are in a position to say: "Give me matter and I will construct a world." For given matter endued with the essential force of attraction, and [all astronomical phenomena] . . . can be traced back to the simplest mechanical causes, which causes we may confidently hope to discover. . . . But can we boast of any such advantage with respect to the meanest plant or insect? Are we in a position to say: "Give me matter and I will show you how a caterpillar is generated"? Do we not in this case, from the very first step in our quest, remain in ignorance of the true inner constitution of the object in question and of the complexity of the manifold parts composing it? It should surprise no one, therefore, when I venture to say that the formation of all the heavenly bodies, the cause of their motions, in short, the origin of the entire present constitution of the universe, will become completely intelligible, before the generation of a single herb or caterpillar can be made wholly clear from mechanical principles.

This passage is, perhaps, capable of being construed as expressing rather an *ignoramus* than an *ignorabimus*. But considering it in conjunction with the uniform tenor of Kant's subsequent writings, we are justified, I think, in saying that he at no time admitted the possibility of bringing organisms within the compass of a scheme of cosmic evolution based upon mechanistic principles. He was, in short, throughout his career a vitalist, though in later life a curiously inconsistent one. The notion of an original "spontaneous generation" of life out of the inorganic always roused his aversion. Yet, as I have remarked, a vitalist may without inconsistency be a transformist; living beings, once produced by non-mechanical causes, may still conceivably change their forms in the course of natural descent. But Kant throughout most of his life looked upon the theories of spontaneous generation and of the transformation of species with so blinding a hostility that he could scarcely tell them apart. We shall find that some thirty-five years of reflection were required before he was able to make so simple a discrimination as to recognize that, from the point of view of his own biological philosophy, the two stood upon a different, even though both stood upon an unsound, footing.

2. *The Review of Moscati on Man's Upright Posture.*—In 1771

[19] *Op. cit.*, 1736, I., p. 43.

Kant wrote a review of a disquisition by an Italian anatomist, Moscati,[20] on the difference between the structure of man and that of the lower animals. Moscati's principal contention was that the upright posture is not "natural" to man, and was not his primitive attitude. Upon this Kant remarks in part as follows:

> Here we have once more the natural man upon all fours—an acute anatomist having traced him back to that condition. Dr. Moscati shows that the upright gait of man is forced and contrary to nature, and that his structure is such that this position, when it has become necessary and habitual, entails upon man various disorders and diseases—clear proof enough that he has been led by reason and imitation to depart from his primitive animal posture. In his inner constitution man is not formed otherwise than as are all the quadrupeds. . . . Paradoxical as this conclusion of our Italian physician may seem, yet in the hands of so acute and philosophical an anatomist it attains to almost complete certainty (*erhält er beinahe eine völlige Gewissheit*). We see from this that nature's first care was for the preservation of man as an animal, in his own interest and that of the species; and for this purpose the posture which was best adapted to his internal structure, to the position of the fœtus, and to protection against dangers, was the four-footed one; but we see also that there lay in man a germ of reason, through the development of which he was to become fitted for society. He consequently assumed the posture most suitable to this, that of a biped. By virtue of this, man, on the one hand infinitely surpasses the animals; but, on the other hand, he is obliged to endure certain disorders that afflict him in consequence of his having raised his head so proudly above his former comrades.

Here, then, Kant readily accepts the doctrine that man was originally a four-footed animal, which, *pari passu* with its unique development of rationality and of the social instincts, assumed the upright attitude. His promptness in making the views of Moscati his own certainly indicates a general predisposition to evolutionary ways of thinking; and, if we had no other expressions of Kant's dealing with the subject more directly, it would be not unnatural to construe this assertion of the descent of civilized man from quadrupedal ancestors as equivalent to an assertion of the mutability of species. Yet the latter doctrine, it must be noted, is nowhere expressed or directly implied in the review of Moscati; and it will presently become clear that Kant would not have regarded it as a legitimate inference from any of his admissions about the earlier condition of humanity. From the time of publication of this review to the end of his life Kant seems to have remained what may be called an anthropological evolutionist; but he deliberately refused to make the transition from this position to a general biological evolutionism.

[20] Moscati was professor of anatomy at the University of Pavia. His book appeared in 1770; a German translation by Beckmann, professor in Göttingen, was published in 1771.

(*To be continued*)

CLASSICS AND THE COLLEGE COURSE

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TWO or three years ago, the acting president of a state university praised the small college for exalting the humanities, for making "study of the great classics compulsory but attractive. It has always found more power for both head and heart in the noble lines of the Iliad and in the majestic music of the Æneid than in study of the nervous system of the frog or the life history of the *Harpiphorus maculatus,* interesting and important as those are."

Somewhat later, a man of great eminence announced that "we have turned away young men and some young women from the great classical ideals of self-sacrifice in fields where they could do the most unselfish work."

Still later, laments have become more numerous and have increased in pungency. It has been discovered that the study of Greek and Latin no longer holds preeminence in colleges and universities, whereas in women's colleges the "humanities are still honored." A distinguished writer of elegant literature has remarked that "our women really have some use for the education of a gentleman, but our men have none."

The acting president, no doubt, pleased his hearers, but there must have been among them some who were surprised to learn that compulsory study of the great classics had been made attractive. The speaker's remarks were elliptical or the compositor dropped the words "to some," which ought to have completed the sentence. The excellent results of this attractive study have not always been apparent. Even fifty years ago, when Harvard and Yale had fewer students than are claimed by some "small" colleges of this day, it was matter of common report that few graduates could read their diplomas and that Latin text-books had been thrust out of theological seminaries, because the niceties of syntax and not the niceties of ancient heresies engrossed the students' attention. If the noble lines of the Iliad and the majestic music of the Æneid have exerted material influence upon the head and heart of youths in American colleges during the last half century, they must have done so through the "Bohn," that essential portion of the average man's equipment.

One, considering the claims made by defenders of classical courses, might imagine that in Greece and Rome there existed the ideal condition, that social and political life were lofty, in contrast throughout

with conditions existing in modern times. He is led to suppose that later periods offer nothing to compare with the Iliad and Æneid; with the intellect of Aristotle; with the morals of Cicero, Seneca and Marcus Aurelius; with the philosophy or excellence of Socrates and Plato; with the daintiness of the Greek lyric poets; with the abandon of Horace; or with the heroism of Marathon and Thermopylæ. He is led to suppose that one must look to Greece and Rome for models of purity and devotion; he is told that only by study of the classical writers can he gain sure foundation in morals and true intellectual polish; that the fulness of the Greek language was the outcome of God's desire to have a fit vehicle for revelation. And finally he is left to gather that our colleges by their teaching of Greek and Latin enable students to come in close touch with all this nobility of thought and life.

Yet no one need feel humiliation because he lives in an inferior age or belongs to a deteriorated race. The sentences extolling the distant past mean nothing; they are but echoes from voices of the long-buried Humanists, which by long reverberation have become polished in form, musical in rhythm. No "literary function" would be complete unless some modern Humanist had repeated them with the fervor of a Thibetan priest.

No one denies that the author of the Iliad had marvelous skill in description, but not a few have regretted that a writer of such ability had no better subject than the quarrels and combats of lustful savages, whose exploits, so vividly pictured, are those of mere brutes. In point of morals, the Homeric poems are not superior to the Kalevala, to which they are inferior in imagery. Of course, this matter is one of taste, but one may be pardoned for supposing that the Kalevala, less extravagant in description than the Iliad, would have gained the stronger hold on popular fame if it too had been translated by Alexander Pope. But neither the Iliad nor the Æneid is superior to Paradise Lost or to the Inferno, which, produced by greater intellects, are free from the grossness which characterizes the Homeric poems.

Aristotle no more typified Greek intellect than Ajax typified Greek physique, or than a building with forty-five stories typifies New York's dwelling houses. He was a giant amid pygmies, a phenomenon in the Greek intellectual sky as startling as was Donati's comet in our physical sky, half a century ago. Like Leibnitz, Kant and Spencer, he broke away from the trammels which bound his contemporaries and devoted himself to the study of actual conditions in search of sure basis for philosophy. Like Leibnitz, Kant and Spencer, he received the maledictions of those who belonged to the prevailing schools. Were he living now he would be but one of many, possibly the chief. It is unjust to compare him with Spencer, as some have done, for the latter lived in an age of greater knowledge and greater advantages. Plato's reputa-

tion is due in no small degree to the fact that his style is ponderous enough to prevent popularization of his works and to conceal defects in his system of social morals; he will continue to be read by only a few and the verdict of four centuries ago is likely to remain unchallenged. But his enduring reputation is due quite as much to his influence on Christian theology as to his profundity of thought.

Socrates, as described by his disciples, was a picturesque but by no means a wholly inviting personality. A careless sloven, of unattractive face and figure, a lounger at street corners, neglectful of obligations to his family, casting slurs publicly on his burdened wife, he was able, in spite of all, to hold the admiration of a thoughtful dreamer like Plato, of a young rake like Alcibiades, of brilliant young men about town like Xenophon and Critias. His range of thought was wide and his versatility remarkable; he could discuss lofty and commonplace topics with equal ease; he was able to speak with authority respecting the immortality of the soul and with equal authority he could advise the fashionable prostitute, Theodote, as to the best methods of coaxing and of retaining her lovers. Socrates was unquestionably a man of great intellect and through his disciples he has exerted great influence on the world; in his personal morals, he was far superior to his surroundings; but he was very far from being the ideal sage.

The essays by Cicero and Seneca are so lofty in tone that the reader is puzzled to determine whether they were written under the influence of a stinging conscience or simply to prove that high thinking may survive low living. Too many moralists then, as in later days, were like guide posts on a wagon—pointing in one direction while traveling in another. It is absurd to look to Greece and Rome for models of purity and devotion. The condition of Greece, literary Greece, was gross beyond conception; it was utter foulness. The lyric poets were dainty indeed, but their daintiness too often was exhausted in admiration of the basest vices. Epictetus, in praising the virtue of Socrates, tells incidentally the whole story of Greek morals; while the high esteem in which the Homeric poems were held shows that, beneath the veneer of civilization, there still existed the savage, even among the scholars. And this was evidenced equally by the glorification of physical perfection; they could not plead the excuse of American college presidents, that it gave them free advertising. In Rome, gross immorality had gained full sway even during the golden age of literature; while, in later times, the moral conditions were so bad that men and women, who would be ordinary mortals in our day, became by contrast with those about them the immortal models of purity and devotion; the dreary platitudes of a Marcus Aurelius shine amid the moral darkness as diamonds in a pile of rubbish.

The models of honor to be found among Grecian statesmen are such

as one might seek to-day among the heroes of Central and South America. The history of Grecian public affairs is a continuous tale of treachery and dishonor. Treaties between the states were made only to be broken; truth was unknown and other nations, however much they might disagree in reference to most subjects, were one in believing that the Greek was always a liar. The petty affairs of Marathon and Thermopylæ have been matched a thousand times in every land. A New York policeman attacking a band of armed ruffians, single handed, without the moral support of 300 or 10,000 companions, is a nobler spectacle than that at either of the Greek battlefields—and it occurs every week. The hand-to-hand combat on Cemetery Hill at Gettysburg, where men fought until barely three scores remained in each regiment and the combat ended only because the survivors fell exhausted, was truer martial heroism than anything in Grecian history.

The modern world unquestionably owes much to Greece and Rome, but much less than many would have us believe. The shackles forged by the Greek and Roman intellect crippled development after the revival of learning and centuries passed before men succeeded in casting them off. One must concede unhesitatingly the brilliancy of many ancient writers, but that is not to say that they excelled or even equalled those of modern times. Modern thinkers excel those of the classic world, because the horizon is farther away; just as civilized man with many concepts excels the Greenlander or Hottentot with his few concepts. And it may be said in passing that Greek civilization was not self-originated. It was but the full blossoming of Egypt and Babylonia, a blossoming which ignored the trunk and roots whence it was derived.

But granting that the ancients did excel the moderns in intellectual power and in loftiness of thought, one is compelled to ask the classicist why college students are not permitted to come into contact with the authors themselves. One may assert, without any fear of successful contradiction, that the teaching of Latin and Greek as given in the vast majority of our colleges during the last half century, has not done this; for few men have acquired in college such familiar knowledge of the language as would enable them to think much of what the author said. Their labor was expended on lexicon work and construction. If these extollers of classic intellect are honest in their plea, why do they neglect genuine study of the authors in the college course? Plato, Seneca, Lucretius and the rest have been done into English in such fashion that the study might be made attractive to the last degree, while the English versions themselves could be used as models of style. But this has not been suggested. The clamor respecting the glory of ancient days is but a plea for restoration of classical courses to the pre-eminent place in college. But it is wholly irrelevant. As well might one urge the grandeur of St. Peter's at Rome to support a demand that

courses in masonry and stone cutting be added to the college curriculum. The plea is not consistent. The Hebrew people and the Hebrew Scriptures have had greater influence upon mankind than that exerted by the Greeks and Romans or their literature, yet no one has demanded that lads be drilled in the accents and paradigms of the Hebrew language. The Greeks owed their civilization to Egypt and Babylonia, yet no one has wept because the study of hieroglyphics and cuneiform is not a prominent feature in the curriculum of secondary schools and colleges. English translations suffice for these languages; it is difficult to conceive why they should not suffice for Greek and Latin.

It is not easy to discover grounds justifying diatribes against the changed attitude toward Latin and Greek as college studies. When one challenges the correctness of the classicist's position, the good man seems to be shocked by the questioner's audacity, he wanders amid generalities and usually finds relief in gloomy reflections respecting this utilitarian age. But the classicist forgets or does not know that, until very recent times, the study of Latin and Greek had nothing whatever to do with mental training, was not supposed to have any special value in that connection. It was as purely utilitarian as the study of bookkeeping in a commercial school, the erection of an anvil in a blacksmith's shop or the purchase of a ticket before entering the train. The would-be student learned Latin just as he learned to read—that the road to knowledge or to preferment might be open to him. In the old universities lectures and text-books were in Latin; many of the Christian Fathers wrote in Greek and would-be theologians needed that language. The university was closed to the man ignorant of Latin as an American college is closed to the man ignorant of English. It was for this reason that when colleges were founded in this land, the chief emphasis was given to the classic tongues; they were established merely as schools preparatory to the university work of theological seminaries, whose text-books were in Latin and Greek.

But the Roman church lost control of the intellectual world; Latin ceased to be the universal language of scholars; lectures and text-books were given in the vernacular. Even theological seminaries, outside of the Roman church, discarded the old text-books and replaced them with modern works of less polemic spirit. Seventy-five years ago all excuse for keeping Latin and Greek in the college curriculum had disappeared. Those languages had held their place because of utility and that had disappeared. But the colleges were here, the largest of them very small; their curriculum was a survival of the past, no longer useful, it was barely ornamental. A new era had been opened by the study of science, but those who controlled the colleges knew nothing of science and most of them thought of it only as an invention of the devil—a new way of

diverting men from consideration of the spiritual to love of the material. Then came the genius who, remembering the classical statement that the first step in education is the study of words, asserted that the chief thing is the study of words; and he discovered that in the study of Latin and Greek words one gains an all-around training, a "mental culture" which is imparted by no other study. With that came the conception that colleges are to give a "liberal education" without any reference to utility. For more than half a century the gospel of culture has been preached by college graduates, who, too often, are themselves living proofs of its falsity.

It is difficult to speak or to write meekly respecting the ceaseless chatter about "culture" and the "education of a gentleman." If study of Greek and Latin in college should make men "cultured," should convert them into "gentlemen," there must be something wrong in the mode of teaching or in the mode of study, for the results are not wholly gratifying. Of course, there may be a difference of opinion as to the meaning of "culture." If it mean comfortable self-satisfaction without basis of knowledge, certainly a very great number of men have acquired "culture" at slight cost; an insignificant quantity of classical or other lore found lodgment in their minds and their chief relic of college days is the recollection that they took the classical course. But if "culture" mean intellectual breadth, judicial attitude of mind, the ability to express one's thoughts clearly, not much of it could be acquired in the old classical course and still less in a modern classical group.

But one is told that a tree is known by its fruits, and the classicist proceeds to prove results by presenting a long list of brilliant authors who studied classics, while he challenges his opponent to show a similar list made up from graduates of non-classical courses. This can not be regarded as a legitimate argument. A field of blasted corn always contains a considerable number of good ears. If one should take the whole product, he might be inclined to say that the classical course is destructive of culture and that the men on the list were those who had escaped the blasting influence of the study; for a very great proportion of the graduates who have entered professional life, exhibit a charming indifference to the rules of rhetoric and notable inability to express their thoughts clearly. But the argument is worthless in either direction. It is absurd as an argument for teaching the classics; nearly all of the polished writers in this land and Great Britain were graduated before the change in curriculum came about; they had to study the classics or nothing.

The writer holds no brief for defence of any special type of education or of any special curriculum but he maintains that a curriculum which ignores utility is wasteful. All training should aim to make a

man conscious of his worth to himself and to his fellows; it should fit him and should stimulate him to make the most of himself so as to leave the world in some sense better than he found it. One may concede that mental polish is very important and at the same time he would be consistent in asserting that to spend years under the polishing process with nothing but veneer to show at the end is an insult to common sense. Something of service should be acquired in the interval. It has been said that the aim of education should be to enable a man to enjoy his leisure; that would make of education a luxury. But one must recognize that, fortunately or unfortunately, all but a very few men have to earn their bread and that to them the years between sixteen and twenty are all-important, being those during which intelligent acquisition of knowledge is made most easily. Since the study of language is essential, the language in the curriculum should be useful. English, German and French are quite as difficult as Latin and Greek, and their literature is sufficiently inspiring. If those languages were taught as the classic languages were taught in American colleges one hundred years ago, the student would have acquired the needed mental polish and he would have the knowledge which is demanded, whether he enter a profession or devote himself to business pursuits.

LEARNING FOREIGN LANGUAGES

By Dr. CHARLES W. SUPER

ATHENS, O.

WHEN we consider that in all the high schools and colleges of christendom, with few exceptions, the pupils are required to study one or more foreign languages, we can not but admit that the subject is one of the utmost importance. And more than this: in the public schools of many of our large cities thousands of children are engaged in the study of English, which is to them a foreign language. Since in the latter case the end in view is solely and directly practical, we need not consider this phase of the problem further in this connection. It is only within the memory of many men now living that the value of such studies has been called in question; or more especially, the relative value of the ancient and modern languages. A few decades ago the latter had either no place or a very subordinate one in the educational curriculum. Every young man who entered college was required to have some knowledge of Greek and Latin. In a few institutions he might pursue a modern language, or perhaps two, but this part of the course was perfunctorily gone over because regarded as subordinate. After a score or less of recitations from the grammar the student was put to reading. Then a few master-pieces were in whole or in part rapidly gone over and that was the end of the program. So far as the principles of language-structure were concerned the student was supposed to have learned them along with his Latin and Greek. Gradually, however, the modern languages received an increasing share of attention, until at the present time in many of our largest universities not five per cent. of the students take Greek, while neither Greek nor Latin is required for graduation. In most high schools the former is not taught, and in all it no longer occupies the post of honor. In this country the contest between the progressives and the conservatives was carried on without much bitterness; but in Germany the latter contested every inch of ground and the discussions of the relative value of ancient and modern languages often gave rise to acrimonious debates. It was in fact a contest between the ins and the outs; between the college professors and what may be called the enlightened public; between the traditional views of education and the practical, not to say imperious, demands of the age. Under the old régime an education was supposed to serve a sentimental rather than a practical end. It was not necessary for either law, medicine, or theology, since

comparatively few young men who entered any of these professions had had any systematic training. Owing, however, to the enormous expansion of commerce and manufactures the public began to insist that educational institutions shall make a wisely directed effort towards enabling young people to meet these demands with an adequate preparation. Education was no longer to be confined to the few; it must be so broadened and extended as to include all who wish to prepare themselves to meet the multifarious claims of the present age. Shortly before his death, Lord Salisbury said: "We do not sufficiently cultivate a systematic knowledge of foreign contemporaneous languages." And further: "If I were capable of prescribing the course that ought to be pursued, I should say that those who have to make their living by commerce in any of its stages, from the highest to the lowest, ought to know French and German, and possibly Spanish, before they think of Latin and Greek." Such words as these uttered by a man who had been educated in the conservative atmosphere of Eton and Oxford are highly significant. They not only reflect the prevailing spirit of the latter years of the nineteenth century, but do credit to the insight and freedom from prejudice of the speaker personally. In fact, it may be said of most of the leading English statesmen that in their public capacity they have always been responsive to the demands of their time, notwithstanding the circumstance that most of them were educated under conditions that were essentially medieval. The prominent place occupied until recently by the ancient languages is a heritage of preceding centuries. For more than a thousand years the former was the only language taught in the schools of Europe outside of the domain of the Greek church. It was, however, not the language of pagan but of christian Rome. The renascence added the Greek, which had become a forgotten tongue; but it directed especial attention to the great pagan writers, above all to Cicero. This change in pedagogical material was logical, since it was the substitution of a literature that had a value in itself for one that was hardly more than an auxiliary to the church, and a language that was a highly cultivated medium for the expression of thought, for one that had been developed along narrow lines. There was no other language and no literature that so well served its purpose. Although the church did not look with favor on this innovation, it continued to make progress to such an extent that the ecclesiastical writers were almost wholly extruded from the schools. Cicero was the model to which all authors who strove to attain to elegance of diction endeavored to conform as nearly as they could. Not only was Latin taught in the higher schools and universities, but the lectures in the continental universities were delivered in this tongue. No other language was used by the German professors until near the close of the seventeenth century, where it continued to be employed to some extent within the memory of men now living. In Germany until

about 1570 fully seventy per cent. of books published were in Latin. Those printed in the vernacular were for the most part of a popular character and considered by scholars beneath their notice. One hundred years later the number of Latin and German books issued from the press was about equal. But in fifty years from that date the proportion of the latter to the former was about as one to two. This effort to keep alive a language that no longer had its roots in contemporary thought required a prodigious amount of labor. Nevertheless, the books written by scholars for scholars thus obtained a wider currency than they would have had if any of the vernaculars had been employed. On the other hand, all works that were intended to be contributions to literature were failures. Petrarch wrote most of his books in Latin; yet they are virtually forgotten while his Italian sonnets are known to all students of his vernacular. Many of his contemporaries spent their time in equally fruitless labor. Dante knew better. Although he wrote Latin with ease, he realized that he could not express his inmost thoughts in an alien tongue. He seems to have been the first man of modern times to discern a truth that Macaulay has expressed in his essay on Frederick the Great: "No noble work of imagination, so far as we can recollect, was ever composed by any man, except in a dialect which he had learned without remembering when or how, and which he had spoken with perfect ease before he had analyzed its structure."

When we try to answer the question whether it is worth while to study a language which conveys little or no information that we can not get in our own we are confronted with a serious problem. We can not draw a hard and fast line between what is useful and what is useless, perhaps not even between what is more and what is less useful. Few persons will deny that the beautiful is also useful and that the esthetic taste is as well worth cultivating as any other of our mental powers. The fairest flowers produce no fruit. Music is absolutely of no value, while sculpture and painting in their higher aspects are equally so. The same affirmation may be made of architecture. No man has championed more vigorously and more eloquently the claims of esthetics than the high priest of utilitarianism, John Stuart Mill. He indignantly repudiates the charge that his system would exclude the cultivation of any art that makes life richer or more worth living than the pursuit of the narrowly practical. There is no room for doubt that a student whose native language is English, with an occasional exception, will get a more correct conception of Plato's philosophy, for example, from Jowett's translation and comments than from the original text. Some knowledge of Greek will be serviceable, but it is not essential. If it be answered that no man of scholarly tastes and scientific training will be satisfied with second-hand information, the patent answer is that if we knew nothing except what we have

learned directly our stock of knowledge would be pitifully small. At the utmost, we can make an immediate inspection of the merest fragment of the immense domain of nature and life, while the entire past has for the most part been transmitted to us through many hands. If we purpose to acquire a language for itself alone there is nothing gained by approaching it in a roundabout way. But there is no doubt that if we wish to lay the foundation for studies of a similar character we can not do better than to begin with Latin. A person who knows Latin well will have far less difficulty in acquiring the Romance languages, barring the pronunciation, than he had with the Latin. The great body of the vocabulary of these languages is derived more or less directly from the ancient tongue. Most words, however, which designate modern objects are formed in various ways. Those words that have their roots in the Latin have merely been modified according to phonetic laws that are now well understood. On the other hand, it is admitted by most teachers who can speak from experience that a knowledge of Latin as gained in our schools is of small service in acquiring French, the Romance language most generally taught. With few exceptions the pupils fail to see the connection between the older and the younger vocabulary and teachers have virtually to begin at the beginning. It is only a small minority of learners that acquire French more rapidly because they have studied Latin previously. It is not too much to say that nobody fully comprehends what is written in those languages now called dead. Part of the difficulty is due to variations in the manuscripts, or to their defective character, but it is also largely owing to the impossibility of ascertaining the meaning of many words. To be convinced of this one needs but to examine the copious notes with which most authors have been provided. A few months ago I had occasion to read some of the later Books of the Æneid, a work that I had not had in hand for a number of years. As long as I had only the text before me I thought I understood the author except in a few passages. But after consulting a profusely annotated edition I was in doubt whether I had got the meaning of more than one verse in ten. So many possibilities and probabilities were suggested that nobody could tell who was right. There is always some difficulty in comprehending a profound thinker. But if we know exactly what he said we can usually come pretty close to an understanding of his meaning. If we are uncertain as to the words he wrote we encounter preliminary obstacles which no amount of ingenuity and intellectual acumen can overcome. It is doubtful whether the mind can be most profitably employed in seeking for something which in the nature of the case can not be found. On the other hand, the effort to acquire the facile use of a language, whether ancient or modern, is always a striving towards an attainable goal. We can obtain expert testimony as to whether we have reached it. There are hundreds of persons now

living who understand Greek and Latin more thoroughly than Plato and Xenophon, than Cicero and Virgil understood them. But in the ability to use them there is a wide difference. In order to understand a language we must know its relation to other languages; in order to be able to use it we need to know it only. It profits nothing for the acquirement of a good style to study a foreign tongue. There is no evidence that the Greek classic writers knew any language except their own. When they discuss problems of philology they usually indulge in puerilities. It was not until the rise of the science of language, about a century ago, that scholars began to see the connection of languages with each other and to classify them according to their affinities. But none of the men who have put upon record the results of their investigations were great writers. It would almost seem as if profound thought and facile expression are incompatible. A knowledge of the etymology of words gives us their history and a clue to their meaning; it does not enable us to understand them exactly, nor aid us in the structure of the sentence. Skill in the use of language is a matter of native ability and something which the most painstaking study can not give us. There is a wide difference between the bald statement of facts and grouping them in their relations in such a way as to gratify the esthetic sense. In the latter the imagination plays a large part; but if it be allowed to become unduly prominent, the result is disastrous.

We have no classical Latin that is suitable for boys. This is a strong objection to giving it a place in the lower schools. Almost all the Latin read in both school and college deals with war and politics. Besides, it is too difficult for beginners. More than a century ago a French teacher compiled an elementary reading-book from good writers by omitting difficult constructions and the less interesting passages. It has been in use in Germany and France ever since his time and has been introduced in this country to some extent. Nevertheless, it is merely the old matter somewhat simplified in form. More recently Professor F. W. Newman made an abridged translation of Robinson Crusoe into Latin with a view to providing reading matter for beginners that is both correct in form and interesting at the same time. But his little volume never found a place in the schools. In this respect the ancients were no better off than we are. As soon as the young Greeks and Romans had learned to read a little they were set to work on Homer or some similar author. No account was taken of their mental immaturity. Perhaps the work has already been done; if not, I am sure that he who shall trace the rise and development of text-books for elementary schools will make an interesting contribution to the history of education.

Although the Latin taught in the European schools for more than fifteen hundred years was not that of the classic writers, the proceeding was in many respects more rational than that now in vogue. The

pupils were taught to speak and to write the language, to use it in the affairs of every-day life. It was not only the Latin of books, but of the playground, of the street, of public discussion. While it was not the speech of the common people, it was the general medium of correspondence, of law and of diplomacy, until superseded by French. One needs but to read the letters of Erasmus or the Letters of Obscure Men to see what a facile medium of expression it was. How easily a foreign language may be acquired is daily demonstrated in the public schools of our large cities. The children of the immigrants who come into this country by tens of thousands from all parts of the world usually learn English, to them a foreign tongue, in a year or less. Were it not so common the phenomenon would be called marvelous. Children do not employ the principle of association; they simply yield to the natural instinct to imitate. Unconsciously they strive to reproduce speech-sounds until they get them to conform to those they hear uttered in their presence. When they begin to talk, usually in the second year, their enunciation and pronunciation are very defective. But by constant though unconscious effort they approximate more and more nearly to the correct sounds until they attain complete conformity. When they are engaged in learning two or three languages at the same time they rarely confound them. They usually answer in the language in which they are addressed. Children under favorable conditions before they are old enough to attend school learn a list of some thousand of words without knowing how. Their vocabulary grows faster than their minds. It is easier for them to learn the words that designate common things in two or three languages than to comprehend an unfamiliar idea. After the age of mental maturity the task becomes more and more difficult and is rarely accomplished correctly. There are, however, here and there persons who can, by an effort, reproduce any speech-sound they hear, as long as their auditory apparatus is unimpaired.

Contrary to the popular belief, the ability to speak several languages is not a mark of mental power. It merely indicates a retentive memory of a certain kind and a knack for imitating sounds. Sir Richard Burton relates in one of his books that once when near Jeddah he was accosted by a man in Turkish. Getting no response, he tried Persian; then the same silence made him try Arabic. When his listener still kept silent he grumbled out his astonishment in Hindustani. That also failing, he tried in succession Pushtu, Armenian, English, French and Italian. When Burton could no longer restrain his risibilities, he admitted his nationality and chatted for some time with the stranger in English, which he spoke very well. Professor Starr says in his "The Truth about the Congo" that members of the Bantu tribes are often met with who speak several languages readily. A recent denominational periodical gives the names of several men who preach in four different languages and a larger number in three. One clergyman is

named who uses Spanish, French, Mandarin, Chinese, Japanese, Italian and English. Of another it is said that he preaches in Burmese, German, English, Spanish, Latin, Greek, Hebrew, Danish, French and Quechua. When one visits an auction-room on the continent of Europe at a point where several languages are spoken and prospective buyers arrive from all parts of the world, he may hear the auctioneer drop one language and take up another until all present have heard in their own tongue what the goods are and the bids. One also meets on the trains traveling salesmen who speak several languages with almost equal fluency. Cardinal Mezzofanti, who died in 1849, spoke fifty-eight languages and knew fairly well about fifty more. He was a man of very ordinary ability except that he had a singularly tenacious memory of an unusual kind, so that when he once heard a speech-sound he never forgot it. About twenty years ago there was an employee in one of the London offices who was able to receive and to send telegrams in twelve different languages. But he soon gave himself up to drink and became so unreliable that the company felt obliged to discharge him.

The testimony regarding fluent speakers in several languages must be received with great caution. It is almost always exaggerated, usually very much exaggerated. While there is virtually no limit to the number of languages one may learn to read rapidly and intelligently, their oral use is almost infinitely more difficult. I have taken careful notes for many years and am convinced that not half a dozen men in a generation can speak even three languages simultaneously with native purity. Some years ago a lady informed me that a friend of hers spoke eight languages as well as if each one was his native tongue. I happened to know that the man himself makes no such preposterous claim. I once made the acquaintance of a young Swiss whom I asked what his native dialect was. He replied that he did not know, since he had been brought up to speak German, French, and Italian. As his English was correct and fluent, although he had been in this country only a few years, he probably told the truth. But his pronunciation betrayed the foreigner in every sentence.[1] Many years ago I was making a foot-tour through the Black Forest with a fellow American. Among other things he informed me that he spoke German like a native. Presently we came to a farmhouse at which he asked for some milk. But he gave the word a wrong gender. An ignorant native might have made a mistake in the grammatical structure of his sentence, or he might have had a local pronunciation, but no native would have made a blunder in the gender of this word, since it is not one of those of which the spoken and the written gender differ. It needs to be remarked, however, that the local dialects vary so widely from each other and from the language

[1] It may be stated in this connection that there are districts in Switzerland in which German is the language of every-day life; Italian the language of the school, and French the language of the church.

of books that the natives of one section have great difficulty in comprehending one another. Historically considered, the attitude of intelligent men toward foreign languages presents some interesting aspects. From about 500 B.C. until well into the third century, everybody who laid any claim to be educated or even well informed, spoke Greek, no matter what his native speech might be. The reader of the history of antiquity meets with ever-recurring surprises at the wide dissemination of a language that is now considered particularly difficult. The utility of this knowledge is never mentioned by any writer: it was taken for granted. While the Greeks themselves rarely knew any tongue but their own, all foreigners possessed a speaking knowledge of Greek. Quintillian, who taught in Rome in the first century, urges his pupils to learn Greek at the same time with their mother-tongue. But he deplores the prevalent custom of teaching Roman children Greek before they know Latin. Yet there were virtually neither grammars nor dictionaries. The language was either picked up from those who spoke it or systematically taught by private tutors. Young men of literary tastes often supplemented the instruction gained at home by a brief sojourn in some Greek city. It should be remarked, however, that the Greeks had no need to acquire any other language for either literature or science, since all that was worth knowing was accessible in their native speech. Roman literature is so pervaded with Greek ideas that it is in no sense an original product. It contains hardly a thought that may not be found in Greek. It was in government alone that the Romans developed their own ideas and profited by their own experience. Although the Greek thinkers wrote a great deal upon the theory and practise of administration, the populace paid no heed and failed everywhere. It is a melancholy fact that they never learned wisdom from their constant succession of fiascoes repeated in every city throughout Greek lands.

There is no best method of teaching foreign languages: the method needs to be adapted to the pupil and to the purpose for which a language is learned. If the mind is to be trained at the same time in logical thinking, the procedure will necessarily be different and the results much slower than when the memory of the learner is to be filled with words and phrases to express concepts which are already in existence. Children learn languages because they can not help it; adults, because they want to. There is besides the much larger number who have to be taught for the reason that they are only half in earnest. It is this class of so-called students who furnish one of the serious problems for teachers. If one wants to teach an adult foreigner the English language there is no better method than that which bears the name of M. Gouin. The teacher suits the action to the word or phrase. He stands, he sits down, he gets up, he points to his eyes, his forehead, his hair, and so on, each time using the appropriate words. If he knows

the language of the foreigner he is trying to teach, so much the better. But this knowledge is not essential. In this way the most ignorant person will soon acquire a few hundred words and phrases which will be a nucleus about which he may enlarge his vocabulary as much as he pleases. Although his pronunciation will be very faulty, he will be able to express himself in a way, and to understand fairly well what is said to him. When teacher and pupil are equally in earnest progress will usually be quite rapid up to a certain point. This point is difficult to pass. For the successful teaching of Latin and Greek to schoolboys a much higher degree of pedagogical ability is essential. Here the teacher has to deal with complex thoughts strangely expressed and more or less above the comprehension of the learner, one of the objects of this kind of instruction being to train his mind up to them. The instructor should not only have a competent knowledge of the language he teaches; he should also have psychological insight, fertility in resources, vivacity of manner and a good measure of literary training. When pupils are only half in earnest or somewhat defective in verbal memory, and the teacher lacks any or all of the above-named qualifications, instruction is "up-hill work," and the results decidedly unsatisfactory. My personal observation of the teaching of Latin and Greek leads me to believe that there is generally too much grammatical hair-splitting and too little reading. A teacher needs to know very little about a language to be able to spend day after day with a class discussing verbal niceties. The serious student of a foreign language soon discovers the method that is best for him, and his progress is usually rapid. In any case the text-book ought to occupy an inconspicuous place.

With the advancing years our educational system will supply more and more fully the needs of the rising generation. The time is not far distant when schools will be called into being wherein everything will be taught that is worth learning. So far as languages are concerned, there will always be persons who will study them for their literature rather than for their practical value. There will always be professors of Latin and Greek, although it is a misnomer to call the latter a dead language. It is more alive than the English of Chaucer. Besides, it may be predicted with confidence that those persons whose native tongue is English will have less and less need to learn any other, except for a more or less permanent residence abroad.

SOME EUROPEAN CONDITIONS AFFECTING EMIGRATION

By ARTHUR CLINTON BOGGESS

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FROM what economic and social conditions do our immigrants from Europe come? This was the question that came to me after reading book after book concerning the immigrant after he has reached America. A diligent gathering from many sources, chiefly official documents, has brought to light many facts of much interest to one who really cares to know the character of the surroundings of those who are thronging our shores. It is the purpose of this article to present some leading conditions in various countries of Europe.

Russia

One eighth of our immigrants are Russian Jews. Peculiar and pathetic is the lot of the Jew in Russia. A law of 1769, modified in 1804 and in 1835, requires that all Jews, except certain specified classes, shall reside within the Jewish pale. The pale is a district beginning immediately south of the Baltic provinces, stretching throughout the west and extending over the south as far east as the Don Army Territory. It has an area of about 362,000 square miles, or less than 20 per cent. of European Russia, and only a little over 4 per cent. of the entire Russian empire. Outside the pale may reside, under certain restrictions, merchants of the first guild—*i. e.*, merchants paying a very high business license—professional persons and master artisans. As a matter of fact 93.9 per cent. of all Jews in the empire live in the pale, 4 per cent. live in the remaining part of European Russia and 2.1 per cent. live in Asiatic Russia. Even the place of residence within the pale is limited by a provision of the notorious May laws of 1882, which prohibits the Jews from buying or renting lands outside the limits of cities and incorporated towns. Jews who owned farm lands in 1882 were not dispossessed, but the law operates to preclude any increase in such holdings.

Restriction upon his place of residence is not the only limitation placed upon the Jew in Russia. In the summer of 1887 the minister of instruction was empowered to limit the number of Jewish students to be admitted into the secondary institutions of learning. This limit was defined as 10 per cent. for the institutions located within the pale, 5 per cent. in the remaining cities and only 3 per cent. in the two capital cities of Moscow and St. Petersburg. The measure was justified as necessary to maintain a more "normal proportion between the number

of Jewish and christian students." The result of this was that the classes in many classical and technical high schools remained half empty, for in the cities where the Jews constituted from 50 to 75 per cent. of the population only 10 per cent. of the high-school students could be of Jewish faith. Hundreds of Russian Jews go to Germany and adjacent countries to attend the higher schools, many making great sacrifices to do so. Jews became converted to Mohammedanism, thus obtaining full admission to higher educational establishments. Thereupon the senate declared that although Jews might be converted to Mohammedanism they did not thereby escape the disabilities of Jews. As Jews who become christians do escape these disabilities, the determination seems to be to drive them to be baptized.

Since 1889 no Jew in Russia can be admitted to the bar except by a special permit of the minister of justice in each case. Russia employs an enormous number of government servants, but except in rare cases Jews are debarred from such employment. Five per cent. of government physicians and surgeons may be Jews. Private practise of law or medicine is almost the only professional work open to Jews, and as a result these occupations are so crowded that a living income can scarcely be made.

To work as a farm laborer is not forbidden, but it is not attractive. Agricultural laborers receive from 25.8 cents per day in sowing time to 77 cents in harvest in southern Russia, and from 12.9 cents to 25.8 cents in northwestern Russia. Board is not furnished by the employer The standard of living can be judged from the fact that the cost of subsistence is officially estimated at from $23.18 to $25.75 per year—somewhat more than 6 cents per day—and that "the regular daily ration of an agricultural laborer consists of about four pounds of bread, which is sometimes supplemented with a cucumber or a few onions." In Russia, especially outside the pale, the greatest poverty is found in the rural districts and the small villages rather than in the cities as in the United States. This is probably due to the general extreme poverty of the peasantry and to the exorbitant taxation. A typical case is that of a man who paid $40 taxes on twelve acres.

Legal restrictions make the Russian Jews swarm in cities, and so overcrowd all occupations open to them that a high standard of living is often wholly impossible in Russia.

Greece

Greece furnished the United States with 19,489 immigrants during the year ending June 30, 1906, and with 36,580 during the succeeding year. Greeks in the United States send to their home country about $7,720,000 annually.

Rural life is of pastoral simplicity and manufacturing is largely of the home variety, although some mills exist. The cotton mills at Piræus, the port of Athens, run eleven hours per day and the wages

of the operatives, chiefly women and girls, average about 27.5 cents per day. There are few milch cows in Greece. Goats and sheep furnish nearly all of the milk for home consumption and the making of cheese. A few cows are found in Athens, but the price of feed is so high that butter sells at 68.5 cents per pound, cream at $3.27 per gallon and curdled milk at 85.3 cents per gallon.

Austria-Hungary

Economic interest in Hungary centers in the development of manufacturing, especially the manufacturing of textile fabrics.

The act of 1907, which it is hoped will mark the beginning of a new era in Hungarian industry, enables the government to grant subsidies and exemption from taxation to those industries which are considered by the minister of commerce to be worthy of encouragement and desirable from a national economic point of view. Subsidies may be in the form of a lump sum or an annual allowance. The act favors the building of workmen's dwellings and enables the municipal and parish authorities to encourage certain industries by grants of money, etc. It further provides that the state, municipal and parish authorities, the institutions maintained or subventioned by the same, and all enterprises engaged in the service of public traffic shall have their initial requisites supplied and their works carried out by home industry.

About $41,000,000 is thus expended annually. The Hungarian mills are in a new milling district and they must import skilled labor, usually from Austria. They also suffer from the large emigration. About 1,000,000 persons emigrated from Hungary during the eight years ending December 31, 1907. The few Hungarians who return from America are arrogant and discontented. Hungary has 460 apprentice's schools, with 66,030 pupils; twenty-two special industrial schools, with 1,177 pupils, and six industrial schools of higher grade. In a factory town where house rent was from $54 to $58 per year, wages in the factory were as follows: picker hands: men, 40.6 cents per day, women, 30.45 cents; cards, 52.78 cents; card grinder, 80.12 cents; draw frames, 30.45 cents; slubbers, 40.6 cents; mules, one spinner, $1.015, two piecers, 71.05 cents, two boys, 50.75 cents; ring spinning, girls, 24.36 cents to 28.42 cents; reelers, 30.45 cents to 40.6 cents. In a Bohemian knitting, linen, and woolen mill weekly wages ranged from $1.01 to $4.26 for female workers and from $1.01 to $7.10 for males. The working day is ten hours.

The factories have by no means displaced home industry. In some parts of Bohemia more than one fourth of the entire population is engaged in home manufacture. In the Riesengebirge paper bags and horn or stone buttons are made. Near Reichenau and Gablonz snuff-boxes were formerly made. As the use of snuff decreased, the making of cheap oil paintings on wood, tin and linen began. When the market is good the whole family works night and day and makes a living. In the Adlerhills weekly wages of $1 to $1.20 are paid, but lost time brings the average to not more than 80 cents per week. Sometimes husband

and wife work alternately eighteen hours a day. Some button makers receive 60 cents per week.

Weavers who make at home silk and Jacquard and art work earn $1.40 to $4 a week. The straw and bast matters earn from 20 to 40 cents a day, but after the "season" the wages are lowered. Wood carvers earn $1.20 to $2.80 a week, and the brush makers at Gabel from $1.60 to $2 a week. The wood carvers at the Wittigtal earn $1.60 to $3.60 a week, and the wood and mat makers at Niemes from $1.20 to $1.60 a week.

People take work home with them from some of the lace factories.

Around perhaps the only table in the only room, in a little house, the family assemble, the man, his wife, the grandparents and children with other members of the family, if there be any. When evening comes on, an oil lamp, a candle, or even chips of wood are the only lights by which they can work. On Thursdays, Fridays and Saturdays the finished articles are taken to the factories and paid for.

"It is very hard now," said one of the lace exporters from Neudek the other day, "to get people in summer to make laces. They prefer to go to work in fields or picking hops, for which they get higher wages than by making laces. Children get 8 cents a day at that time and adults from 25 cents to even 40 cents, and of course we can not afford to pay such high wages for lace making."

Austria-Hungary's housing problem becomes acute in her city and factory districts. In 1900, 43 per cent. (592,134 persons) of the inhabitants of Vienna lived in houses of one room, exclusive of kitchen. In Reichenberg, a decade earlier, 57.5 per cent. of the dwellings, and in the suburbs 79.2 per cent., were without kitchens. In many of these houses the inmates did their manufacturing work. Similar conditions were found throughout the empire. Conditions in Reichenberg have not materially changed since 1890, but lately in other parts of Austria and Hungary a strong movement has set in for the erection of suitable dwellings for the poorer classes. The chief improvements are in the size of rooms, lighting, ventilation and rate of rent rather than in the number of rooms. Many of the model flats have but one room and an attic or one room and a kitchen. In some places tenants are forbidden to take lodgers. The government encourages the building of homes of a certain specified desirable type by exempting the builders from certain forms of taxation. In several cases model houses are rented at such a figure as to yield but 3 per cent. on the investment.

Italy

Italy has more than 650 mills for the manufacture of cotton fabrics. By far the larger part are in northern Italy, but the government is trying to increase the number of mills in southern Italy.

To this end land has been offered free of cost for mill sites, taxes will be remitted for ten years, and textile machinery for mills so locating will be admitted free of duty.

Labor is cheaper in the south, but it is also less efficient and mills are there farther from their sources of supply. The number of mills in the south may, however, be expected to increase. Wages in the

south range from 29.1 to 38.6 cents per day and in the north from 38.6 to 58 cents. Country mills pay much less than city mills.

The average daily wages paid in a country mill near Milan have gradually increased from 30.9 cents for men and 11.6 cents for women spinners in 1871 to 47.3 cents for men and 36.1 cents for women in 1907, while for weaving the wages have increased from 15.4 cents to 39.6 cents in the same period. The hours of labor have also been decreased from twelve to ten and a half per day. The number of days worked per year is about 290.

Some mills still run eleven hours per day.

Two of the several Italian strikes of 1907 will be described for the sake of their interesting data concerning grievances and wages.

Scanzo (Bergamo).—On March 9 there was initiated a strike at the weaving plant of Carlo Caprotti by 3 men and 198 women weavers making 31 cents a day, 46 girls running cop winders at 16 cents a day, 50 spoolers at 21 cents a day, 12 warpers at 29 cents a day, and 16 drawing-in hands at 35 cents a day. The weavers demanded that the fortnightly minimum requirements be reduced by one piece of cloth, the cop winders, spoolers and warpers asked an increase in wages. Fourteen men remained employed until the fourteenth at 39 cents a day, and 20 boys at 19 cents a day. The strikers, notwithstanding they were not organized, were assisted by the Catholic Society of Labor of Bergamo. They obtained a reduction of the minimum required and also a concession that loom stoppage not by their fault be not counted. The increase of wages will be settled by an arbitrator. The work began again on March 16.

Leghorn.—The firm Cantoni-Coats for the manufacture of sewing thread gives work to 250 men at 58 cents and to 950 women at 23 cents per eleven-hour day. The firm wishing to introduce in the several branches "lustraggio and tavelle" (glazing and roughing), a system of labor that meant a reduction of wages, the whole body of operatives on July 8 initiated a strike, asking a general increase of wages. The labor union of Lucca directed the strike, the president of the local chamber of commerce intervened, and the firm granted an increase of 5.8 cents per day during apprenticeship and of 2.9 cents for those on the roughening work, and besides made a formal promise for a general increase of the rate remuneration. On July 29 work was resumed. During the strike $4,053 was expended in assistance to the strikers.

Italy, in 1902, passed a law to take effect in 1907, prohibiting the night work of women and children in mills. As women and children constitute two thirds to three fourths of the operatives, the law practically meant that the mills had to be doubled. Most of the mills were prepared for the change by 1907.

Italian operatives necessarily live cheaply. In Piedmont and Lombardy the regular menu is: breakfast—bread and milk mush; dinner—spaghetti (potatoes and milk mixed into a porridge), polenta (cornmeal mush), and wine; supper—cold spaghetti porridge, cold polenta, cheese and some wine. Dinner in the middle of the day is the heartiest meal, and enough spaghetti porridge and polenta are then made up to last for both dinner and supper, being eaten cold for the latter meal. Chestnuts are also a staple article of food, and radishes, with olive oil and other vegetables, when procurable. Wine is within the reach of all.

The better class of table wine costs 7⅓ cents per quart, and less in bulk. There has been a notable increase in the consumption of meat in the kingdom. At Genoa the consumption of meat has increased 50 per cent. in fifteen years; at Milan, 50 per cent. in seven years; at Rome about 10 per cent. in seven years. At Naples, since 1902, the number of beeves slaughtered has increased 150 per cent. At Milan the number of horses slaughtered in 1897 was 4,586, in 1907, 7,132. Horse meat retails at 6 to 9 cents per pound. The per capita consumption of meat ranges from 8.8 pounds per year in the extreme south to 163.43 pounds in the province of Milan.

Coral manufacture is an important industry in Naples. The coral is sorted, cut in pieces, filed or engraved, and polished. Women do the less skilled work and receive from 40 to 60 cents a day. Men receive from 60 cents to $1.20. Very skilled engravers receive relatively high wages, but rarely as much as $3 a day.

A consul at Messina, commenting upon the effects of emigration, said that prices of both labor and foodstuffs had been raised, but that the standard of living of the laborer had become markedly higher. A part of this result was attributed to the money sent back by persons working in the United States. Italians who return from the United States are a disturbing factor, as they do not return to their old standard of living and they make those about them discontented with their lot.

Italian farmers are accustomed to intensive work. They make expert truck gardeners and vineyard tenders.

The state, voluntary organizations, and, to some extent, religious societies have been doing an increasing amount of progressive and intelligent social work in Italy. Already the effects of this work are becoming apparent.

Switzerland

Swiss manufacturers have several difficulties to combat. There is such a scarcity of workmen that Italians, Germans and Austrians are imported. No night work is allowed, while in Italy *men* can work at night. Many mills are in places difficult of access, thus making the cost of transportation high. All coal and almost all machinery must be imported. In spite of these difficulties considerable manufacturing is done.

The Swiss are patient, industrious workers, and however small their wages they always contrive to have an account at the savings bank. In the country their diet seems to be coffee, bread and potatoes three times a day, with meat and wine on Sundays.

The standard of living of the workmen in the cotton mills can be judged by comparing the wages paid with the prices of food. The following table presents the data for four separate mills.

In but one mill would a day's wages purchase so much as four

WAGES PAID

	I.	II.	III.	IV.
Blow room:				
Head man			$1.06	$ .74
Workman	$ .65	$ .59	.60	.53
Waste man	.61	.55	.56	.56
Cards:				
Head man	1.42	.85	1.16	1.12
Card grinder	.77	.67	.62	.66
Can boys	.61	.51	.59	.51
Lap carrier	.60	.51	.54	.53
Oiler				.42
Draw-frame girls	.48	.43	.41	.40
Speeders:				
Head man	1.22	.85	1.06	1.10
Oiler	.61		.64	.49
Speeder hands	.65	.50	.45	.55
Creelers			.35	.39
Ring spinning:				
Head man	1.14	1.07	.87	1.16
Oiler	.61	.61	.67	.44
Spinner	.56	.31	.43	.43
Doffer			.31	.33
Machine shop:				
Head man	1.62	1.22	1.72	
Average per day	.63	.50	.47	.51

PRICES OF NECESSARIES

	I.	II.	III.	IV.
	Cents	Cents	Cents	Cents
Bread, average quality, one pound	3.13	2.95	2.63	2.95
Meat, one pound	15.68	14.77	13.09	16.59
Flour, one pound	4.4	3.5	4.31	4.31
Potatoes, one pound	.72	.72	.9	.9
Sugar, one pound	4.8	8.09	4.8	6.09
Coffee, one pound	20	28.5	19.3	15.77
Salt, one pound	1.27	1.86	.9	1
Milk, one quart	3.9	4.1	3.7	3.9
Kerosene, one quart	3.5	8.5	4.1	4.2
Beer, one quart	7.7	6.3	5.7	6.7

pounds of meat and in two cases more than four days' wages were required to pay for a fifty-pound sack of flour. Those whose wages were below the average—and they are the large majority—would fare worse.

Of the 2,000 people employed by the Maschinenfabrik Oerlikon, Zurich, 50 per cent. represent a floating force. An increasing tendency in workmen to float about is causing an increase in wages, but wages in Switzerland in machine shops are not so high as in Berlin. A good tool man at Oerlikon receives 96 cents to $1.35 per day. Fitters of the best class receive $1.35 to $1.544 per day; shop men, for varied sorts of work, 77.2 cents to 96 cents per day. The cost of living for workmen in Zurich in proportion to the cost in America is, roughly, in the ratio of about 1 to 2½ or 3. The Oerlikon firm provides both breakfast and dinner for such employees as choose to purchase them. Dinner costs about 10 cents and generally consists of good soup, pork and beef, cabbage, potatoes, and bread and butter. All except soup is served out in portions For breakfast milk and coffee, bread and butter are provided,

and the firm pays one half. The reason for serving breakfast is to insure that the men start work in the morning on nourishing food. Baths, including soap and towel, are provided at 2 cents.

The Swiss Locomotive and Machinery Works, Winterthur, are undertaking a limited amount of welfare work. About fifty families are housed in neat dwellings owned by the company. The rent varies from $41.68 per year for three rooms to $57.90 for four rooms of medium size and $69.48 for four large rooms. Nearly all of the men residing in these houses are members of the firm's fire brigade. Baths are provided here as at Oerlikon. In general, Europe has made considerable advancement in providing houses, meals, baths, and pensions for workingmen.

Germany

Berlin workmen in machine shops obtain, as a rule, better wages than those in other parts of the empire, and the Berlin workmen are unexcelled at their respective trades. In the machine-tool plant of the Ludwig Loewe A. G. Works, at Berlin, the workmen can usually make on piece work 20.23 cents per hour. The lowest guaranteed wage is 12.614 cents per hour. Workmen can obtain houses of one room and a kitchen at an annual rental of $57.12 to $64.26 and houses of two rooms and a kitchen at $119.96 to $134.24. In the Hohenzollern A. G. Locomotive Works, Grafenberg-Düsseldorf, and the Hanover Locomotive Works, respectively, expert workmen receive, on the average, 16.6 cents per hour. The Hanover works own about 150 houses which rent at an average of $3.57 per month—a sum merely sufficient to keep them in repair. The houses contain from four to six rooms and may be occupied by one or two families. In many cases one room and a kitchen suffice, but two rooms and a kitchen are more common. The Benrather Works, at Benrath, board and lodge their unmarried workmen for 23.8 cents per day.

In the textile industries lower wages are paid than in the machine shops. Barmen is a great center for textile industries. Wages average 80 cents per day, but are increasing. Weavers on special work get as high as $1.43 a day. In the most important single cotton mill in Germany, at Augsburg, Bavaria, the picker-room hands and the carders get 50 to 70 cents a day. On two 900 self-actor mules the spinner averages about 90 cents a day, the piecer 71 cents, and each of the two creelers 35 cents. Weavers, on an average, run three looms apiece and make about 80 cents a day. The term of apprenticeship is two years, during the first six months of which 24 cents a day is usually paid. Houses of three rooms rent for $23.80 to $33.32 a year. The working day is ten hours. Wages in the mills in Saxony are distressingly low. At Plauen, Saxony, overseers receive $5.71 to $9.52 a week, rarely more. Operatives average $3.81 a week. Man, wife and several children live on this wage, although the wife is sometimes a wage earner. Rent of

the two-roomed houses is rarely less than $2.38 and is usually about $3.57 a month. The chief food is potatoes and salt, bread, and a pepper soup made of water, bread, a little fat, and plenty of pepper. Meat is rarely eaten, and when indulged in is usually in the form of soup meat or sausage.

Operatives generally eat five times a day, and rye bread is nearly always taken. The first breakfast consists of coffee, made chiefly of roasted grain, and a piece of bread or roll. Sometimes a bowl of hot water with a little flour stirred in is taken instead of coffee. The dinner is at midday. The morning, afternoon and evening meals are much lighter, and in them beer often occupies a place.

A spinning master, in the woolen mills at Aix-la-Chapelle, receives $9 to $14 per week; operatives, $5 to $6; other help, mostly girls, $4.50 to $5; weaving master, $9 to $14; regulators or setters, $7 to $10.50; weavers, $6 to $8.40; head darner, $8 to $10; head darner's assistants, $5 to $7. Prices of food, clothing and fuel in Aix-la-Chapelle are: beefsteak, per pound, 27 to 30 cents; other beef, 20 to 25 cents; ham, 40 to 55 cents; sausage, 10 to 30 cents; pork, 20 to 25 cents; horse, 10 to 12 cents; flour, 3 to 6 cents; potatoes, 1 to 2 cents; dried Bosian prunes, 6 to 8 cents; California prunes, 15 to 18 cents; cheese, 10 to 30 cents; butter, 10 to 40 cents; white bread, 4 to 6 cents; black rye bread (4 lbs.), 12 to 14 cents; workmen's shoes, $1.25 to $2.25; workmen's suits, $1.50 to $2.00; workmen's dress suit, $3.00 to $8.00; coal (per 100 lbs.), 40 to 55 cents.

More than 25 per cent. of the factory operatives of Aix-la-Chapelle have their homes in Holland, whence they come each morning (some as far as thirty miles) and return each evening. For this they pay 75 cents a week for the "workmen's railroad ticket." They mostly own little houses with one fourth to one acre of garden or field. They have a cow and a few pigs or keep some goats, and bake their own bread. They are allowed a few days off each year to till their fields. They manage to live very cheaply; a family of father, mother and four children will live on 60 cents a day. Flour is 20 per cent. and meat 25 per cent. cheaper in Holland than in Aix-la-Chapelle. Most of these country home dwellers have a savings-bank account or deposit of a few hundred dollars.

Another 15 per cent. of the workers live in adjoining German villages where they either own little fields or pay $12 to $14 rent per year. In the city a two-room house rents at $4 to $6 per month.

Twenty-five per cent. of the glass grinders in Bavaria work more than eleven hours per day. In the Breslau district 58 per cent. of the glass-grinders work from ten to eleven hours per day. Japan has become such a keen competitor in the glass industry that Germany fears opposition if a law limiting the hours of labor be passed.

The manufacture of dolls is a business of no small dimensions in Germany. In the doll factories the minimum weekly wages are: Male adults, $2.85; male minors, 95 cents; female adults, $1.80; female minors, 85 cents and the maximum wages are less than double these, being $4.75, $1.45, $3.60 and $1.55, respectively.

GENIUS AND STATURE

By CHARLES KASSEL
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THAT greatness and loftiness of stature are rarely found together is one of the leading statements of Lombroso's "Man of Genius," and the eminent Italian, in support of his assertion, arrays a respectable list of names. Nor does Lombroso stand alone in this opinion. The notion is a common one—even a proverbial one—and now and again some voice rises from press or periodical with this boding message to the stalwart sons of men.

If the biographies, however, in the average American library afford a just test of its truth, this belief must be gathered to the limbo of popular errors and delusions. So far, indeed, from supporting the statement of the great criminologist, the testimony of biography fixes the average stature of men of eminence at a point above the middle height.

In default of statistical data ready to hand—the dearth of reliable material upon this question being quite marked—the writer has turned through the biographical section of a general public library situated in the city of his residence. Of the lives of two hundred and thirty distinguished men thus examined, those of one hundred and three supplied the information sought either in exact figures or by way of general statement; and of these personages it appears that sixteen were of middle height, fifty-eight above and twenty-nine below. In many instances the stature was merely described as "medium," or above or below, and in tabulating the result we have assumed the correctness of this classification, although it is far from certain that in reality the terms bore the same meaning to all writers. Where, however, the stature was given in feet and inches, we have adopted as the standard of medium height five feet seven inches. This is manifestly too low for America, and is likewise too low for England, since, as we are told by H. H. Donaldson in "The Growth of the Brain," five hundred and seventeen observations among all classes gave 67.7 inches as the average stature for men in England. For the civilized world, however, the average would probably be so far lower than that of England and America as to make the figures we have mentioned a fair standard. Even, however, were 5 feet 8 inches to be used for middle height, the result, so far as the present paper is concerned, would not be disturbed, since none of the statures given fall within this disputed margin. It

will be observed, moreover, that our discussion is confined to the statures of men. Those of women are notoriously lower, and the two can not well be treated together in an article of short compass.

Towering above all the historic characters thus gathered before the mind's eye is the immense form of Charles Sumner with his 6 feet 4 inches. Beside him, only an inch and a half less in height, stands Thomas Jefferson, while near these two are Charles Godfrey Leland and Andrew Jackson with statures of 6 feet 2½ and 6 feet 1 inch.

Described as "over six feet" are Samuel Adams, Bismarck, Samuel P. Chase, Captain Cook, Jonathan Edwards, Eugene Field, Henry Fielding and Walt Whitman, while Charles Darwin ("about six feet"), Alexander Dumas, the elder, James Monroe ("six feet or more"), Bayard Taylor ("six feet at seventeen"), Alfred Tennyson, General Thomas and George Washington must be ranged with celebrated men six feet in height.

Another group—still of majestic presence—is referred to as "slightly under" or "a little below" six feet, and in this we find the names of Henry Ward Beecher, Rufus Choate, Sidney Lanier and Daniel O'Connell. The remainder are of less impressive height—Benjamin Franklin, Albert Gallatin, John Ruskin, Robert Louis Stevenson and Daniel Webster, who could claim five feet ten inches, General Charles George Gordon, whose stature was five feet nine inches, and Washington Irving, who was 5 feet 8½ to 9 inches.

In addition to these individuals there is a goodly company spoken of by the biographers as "tall"—Matthew Arnold, Louis Agassiz, William Cullen Bryant, Julius Cæsar, Charlemagne, Charles XII. of Sweden, Christopher Columbus, Stonewall Jackson, General Sam Houston, Leigh Hunt, Edward Fitzgerald, Ben Johnson, Chief Justice Marshall, Sir Walter Scott, Robert Southey ("very tall"), Phillips Brooks ("of great height"), Wm. M. Thackeray ("above medium height"), Patrick Henry, Lorenzo de Medici, Francis Parkman, Coventry Patmore, Peter the Great, Percy Bysshe Shelley, Sidney Smith ("of middle height, rather above than below"), Thaddeus Stevens, N. P. Willis, Richard Strauss and John Bunyan.

Described as of "medium height" are Robert Browning, John Adams, Sir Thomas More, Wm. Hazlitt, Julian, S. S. Prentiss, Lord Palmerston, Duke of Wellington, William the Silent, Sir Arthur Sullivan, Frederick the Great ("not of imposing stature"—Carlyle), Admiral Nelson ("a little man of about medium height"), Schubert ("moderately tall"), and as 5 feet 8 inches we have the names of Grant, Theodore Parker and Rossetti.

Under medium height were, according to their biographers, Admiral Farragut, who was 5 feet 6½ inches, Oliver Wendell Holmes, Paul Jones and General Phil Sheridan, each of whom was 5

feet 5 inches, Beethoven, who is described as "scarcely over 5 feet 4, Vienna measure," John Keats ("little over 5 feet"), Stephen A. Douglass ("scarcely over 5 feet") and Swinburne and Whistler, whose statures are given as "five feet or so." We should add, however, that the figures as to Swinburne and Whistler, like those with reference to Edward Fitzgerald in an earlier paragraph, were derived not from authoritative biographies, as in the case of all the other names, but from magazine articles which chanced to come under the writer's observation while pursuing these investigations.

As "short" or "under medium height" we find John Quincey Adams, Andrew Carnegie, William Ellery Channing, Chaucer, Alexander Hamilton ("much below"), Ibsen, Charles Lamb, Napoleon Bonaparte, Thomas B. Macaulay, John Milton, Thomas Moore, Alexander Pope, Robespierre, Savanarola, Wm. H. Seward ("small"), Thoreau, Martin Van Buren, Chopin and Michael Angelo.

The materialist who believes life and personality are but the florescence of physical forces, and the brain not the urn but the creative agent of thought, may rejoice over the fact that of those men of genius who were low in stature no few are expressly mentioned as having had large heads—namely, Stephen A. Douglass, Alexander Hamilton, Charles Lamb, Macaulay, Napoleon and Beethoven. On the other hand, he will be confronted by the fact that a number of tall men of a high order of talent have possessed craniums of proportions not calculated to inspire respect—notably Chief Justice Marshall, Washington, Captain Cook and, in a peculiar degree, the poet Shelley, who shared this characteristic with his fellow minstrels Byron and Keats.

The circumstance is a curious one, if our catalogue of names may be relied upon as a basis for deduction, that naval commanders have been of low stature. The fact that coast-dwellers, unlike mountain-peoples and forest-folk, are usually short in body may not be without a bearing upon this; since sea-faring men are apt to spring from coast-dwelling races.

The roll of names and statures which we have given suffers in its usefulness because of the undue predominance of American names. The effect of this is plainly to heighten the average stature. The need of a table of names, sufficiently large to obviate errors from non-essential causes, and carefully sifted so as to exclude men of merely accidental distinction, is a condition which meets the inquirer at the threshold of the subject, and even this table of names would have to be grouped by races and regions, and separately studied, in order that comparisons within each region and nationality might be made.

CERTAIN CHARACTERISTICS OF THE SOUTH AMERICANS OF TO-DAY

By Professor HIRAM BINGHAM
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UNTIL very recently, the average newspaper article and the talk of the average person, so far as it went, took it for granted that South America was a region devoted to revolutions and fevers, where individuals called South Americans spent their time in a cheerful state of anarchy. There are novels and plays that still maintain this pleasing fiction, although, thanks to a recent enlightened secretary of state and an energetic director of the Bureau of American Republics, we know much more about South America than we did. In fact, we are beginning to distinguish to a certain extent between the stable republics of Argentina and Chile and the troublesome ones like Venezuela, but we still like to speak of the people as "South Americans" and it is fair to do so.

A race is rising in South America that is different from anything that the world has yet seen. It is a hybrid product composed for the most part of the blood of Spaniards and South American aborigines, such as Quichuas, Araucanians and Abipones. There is also an infiltration of various European stocks. It is true that there are differences between the peoples of the several South American republics, just as there were great differences between the aboriginal Indian tribes. At the same time, there is so much of the blood that came from the Hispanic peninsula and this has been for so many generations the dominant factor, that it is possible to consider the people of South America more or less as a whole.

It must also be admitted at the beginning that there are many South Americans who can not be included in any general criticism. There are many families of pure Castilian ancestry who rightfully resent any implication that they are hybrids because they are South Americans. And they would also prefer not to have the pure-blooded Indians counted as South Americans, although the latter constitute a majority of the population in several republics, notably Bolivia and Peru. We ought easily to be able to appreciate the fact that such a broad term as "South American" must include many diametrically opposite types, for foreigners are finding it increasingly difficult, nay almost impossible, to define and fix the limit of our own characteristics as "Americans." A hundred years ago it was simple enough. People of English descent dominated things everywhere. To-day we are a

mixture of fifty races, and it is hard to say who has the right to be considered the typical Bostonian or New Yorker, he of English or Dutch extraction or he of Irish or Jewish ancestry.

Things are not quite so bad in South America, for most of the republics have seen but comparatively little immigration and the politics of South America are to-day directed by men of Spanish and Indian descent. Even in Argentina, where the census shows a more cosmopolitan population than in any other republic, the game of politics is controlled almost exclusively by Argentinos whose ancestors were Spaniards and Indians. In another generation this may be changed, for, thanks to an increasing and extensive immigration, the Argentine type is becoming more and more Europeanized. In Bolivia and Peru, on the other hand, owing to the scarcity of available and accessible agricultural lands and the consequent lack of immigration, the typical politician is nearer a simple cross between Spaniard and Indian. In Chile there is more Anglo-Saxon and Teutonic blood, while in Venezuela and Colombia there is very much less. In Brazil there is more African. In fact, one is almost inclined to leave the Brazilians out of the case, for their ancestors have been of a very different stock from that in the Spanish-speaking republics; Portuguese instead of Spanish, Amazonian Indian instead of mountain Indian, and far more African blood than in any other republic. Nevertheless, they too, by the very fact of their being a mixture of Caucasian, American Indian and African, living under similar geographical conditions, have many of the same traits that are found elsewhere on the continent.

Making due allowance then for the exceptions, what are the characteristics of the South Americans of to-day?

As one travels through the various South American republics, becomes acquainted with their political and social conditions, reads their literature and talks with other American travelers, there are a number of adverse criticisms that frequently arise. I shall attempt here to enumerate some of them, to account for a few, and to compare others with criticisms that were made of the people of the United States half a century ago by a distinguished English visitor.

Although it is true that the historical and geographical background of the South Americans is radically different from ours, it is also true they have many social and superficial characteristics very like those which European travelers found in the United States fifty years ago. The period of time is not accidental. The South American republics secured their independence nearly fifty years later than we did. Moreover, they have been hampered in their advancement by natural difficulties and racial antipathies much more than we have. Although the conditions of life in the United States as depicted by foreign critics seventy-five years after the battle of Yorktown, were decidedly worse than the conditions of life in South America seventy-five years after

the battle of Ayacucho, the resemblances between the faults that were found with us fifty years ago and those that are noticeable among the South Americans of to-day, are too striking to be merely coincidences. It is surely not for us to say that there is anything inherently wrong with our southern neighbors if their shortcomings are such as we ourselves had not long ago, and possibly have to-day.

The first criticism that one hears and the first one is likely to make after getting beyond the pale of official good breeding in South America, is that the manners of the ordinary South American are very bad. Let the traveler who is inclined to take such a state of affairs too seriously, read what Dickens wrote about us and our ways in 1855 in "American Notes" and "Martin Chuzzlewit." It was a faithful picture of a certain phase of American life. Furthermore, it paints a condition of affairs worse than anything seen in South America.

Travelers who are prone to find fault with the service at South American hotels and restaurants, should ponder on Dickens's description of the dining room of a New York boarding house in his day.

In the further region of this banqueting-hall was a stove, garnished on either side with a great brass spittoon. . . . Before it, swinging himself in a rocking-chair, lounged a large gentleman with his hat on, who amused himself by spitting alternately into the spittoon on the right hand of the stove, and the spittoon on the left, and then working his way back again in the same order. A negro lad in a soiled white jacket was busily engaged in placing on the table two long rows of knives and forks, relieved at intervals by jugs of water; and as he travelled down one side of this festive board, he straightened with his dirty hands, the dirtier cloth, which was all askew, and had not been removed since breakfast.

It is indeed hard to overlook the table manners of the average South American. But how many years is it since North Americans were all reading and conning "Don't! A Guide to Good Manners"? It is less than a quarter of a century since our self-conscious use of the fork on all possible (and impossible) viands showed that we felt the need of improvement.

To one inclined to criticize the speed with which a company of South Americans will dispose of their food, let me recommend Dickens's American boarding house table where

Very few words were spoken; and everybody seemed to eat his utmost in self-defence, as if a famine were expected to set in before breakfast-time to-morrow morning, and it had become high time to assert the first law of nature. The oysters, stewed and pickled, leaped from their capacious reservoirs, and slid by scores into the mouths of the assembly. The sharpest pickles vanished; whole cucumbers at once, like sugar-plums; and no man winked his eye. Great heaps of indigestible matter melted away as ice before the sun. It was a solemn and awful thing to see. Dyspeptic individuals bolted their food in wedges; feeding, not themselves, but broods of night-mares, who were continually standing at livery within them. Spare men, with lank and rigid cheeks, came out unsatisfied from the destruction of heavy dishes, and glared with watchful eyes upon the pastry.

The conversation of a group of young South Americans is not such as appeals to our taste. There is usually too much running criticism on the personal qualities and attractions of their women acquaintances. To them it seems doubtless most gallant. At all events, it is not sordid, as was that conversation which Dickens describes as "summed up in one word—dollars."

When Dickens visited America, he remarked the frequency of the expression, "*Yes, sir,*" and made a great deal of fun of us for our use of it. Singularly enough, the Spanish "Yes sir"—"Si senor" is so extremely common throughout South America as to attract one's attention continually.

Another thing that Dickens notices was our tendency to postpone and put off from day to day things that did not have to be done. Yet there is no more common criticism of Spanish-Americans than that known as the "Mañana" habit. You will hear almost any one who pretends to know anything at all about Spanish-America say that the great difficulty is the ease with which the Spanish-American says "Mañana." Personally, I do not agree with this criticism, for I have heard the expression very seldom in South America. It is true that it is hard to get things done as quickly as one would wish, but I believe that the criticism has been much overworked. Dickens was undoubtedly honest in reporting that the habit of postponing one's work was characteristic of the "middle west" as he saw it, but such remarks would be greatly resented to-day and would not be true.

In many South American cities one is annoyed by the continual handshaking. No matter how many times a day you meet a man, he expects you to solemnly shake hands with him just as did those western Americans who annoyed "Martin Chuzzlewit."

So also with "spitting." With others, I have been repeatedly annoyed, not only in the provinces, but also in the very highest circles of the most advanced republics, by the carelessness of South Americans in this particular, even at dinner parties. But how many years is it since "The Last American" was prophetically depicted by J. A. Mitchell as sitting amid the ruins of the national capitol with his feet on the marble rail, spitting tobacco juice? One can hardly ride in our street cars to-day without being reminded that only recently have the majority of Americans put the ban on spitting. The fact that there are already printed notices in some of the principal South American cathedrals begging people, in the name of the local "Anti-Tuberculosis Association," not to spit on the floor, shows that this unpleasant habit will undoubtedly be eradicated in considerably less than fifty years after we have ceased to offend.

We also dislike intensely the South American habit of staring at strangers and of making audible comments on ladies who happen to be passing. Unfortunately, this is a Latin habit which will be hard to

change. The South American has a racial right to look at such customs differently. But if some of his personal habits are unpleasant and even disgusting from our point of view, there is no question that we irritate him just as much as he does us. Our curt forms of address; our impatient disregard of the amenities of social intercourse; our unwillingness to pass the time of day at considerable length, and enquire, each time we see a friend, after his health and that of his family; our habit of elevating our feet and often sitting in a slouchy attitude when conversing with strangers are to him extremely distasteful and annoying. Our unwillingness to take the trouble to speak his language grammatically and our general point of view in regard to the "innate superiority" of our race, our language and our manufactures are all evidences, to his mind, of our barbarity. We care far too little for appearances. This seems to him boorish. We criticize him because he does not bathe as frequently as we do. He criticizes us because we do not show him proper respect by removing our hats when we meet him on the street.

Furthermore, he regards us as lacking in business integrity. We are too shrewd. Our standard of honor seems low to him. In fact, a practical obstacle with which one accustomed to American business methods has to contend in South America, is the extreme difficulty of securing accurate information as to a man's credit. Inquiries into the financial standing of an individual, which are regarded as a matter of course with us, are resented by the sensitive Latin temperament as a personal reflection on his honesty. It seems to be true that the South American regards the payment of his debts as a matter more closely touching his honor than we do. He is accustomed to receiving long credits; he always really intends to pay some time and he generally manages to raise installments without much difficulty. Yet when pressed hard in the courts, he is likely to turn and resent as an intentional insult the judgment which has been secured against him. I have known personally of a case where a debtor informed his creditor that it would be necessary for him to come well armed if he accompanied the sheriff in an effort to satisfy the judgment of the court, for the first man, and as many more as possible, that crossed the door of his shop on such an errand would be shot. This we criticize as defiance of the law. To the South American, the law has committed an unpardonable fault in venturing to convict him of neglecting his honorable debts.

It is unfortunate that the South Americans themselves are generally quite unaware of their failings—a species of blindness that has frequently been laid at our own doors. It is due to a similar cause. South American writers who have traveled abroad and seen enough to enable them to point out the defects of their countrymen rarely venture to do so. The South American loves praise but can not endure criti-

cism. It makes him fairly froth at the mouth, as it did the Americans in the days of Charles Dickens's first visit. So the pleasant-faced gentleman from Massachusetts, Mr. Bevan, told young Martin Chuzzlewit:

> If you have any knowledge of our literature, and can give me the name of any man, American born and bred, who has anatomized our follies as a people, and not as this or that party; and has escaped the foulest and most brutal slander, the most inveterate hatred and intolerant pursuit; it will be a strange name in my ears, believe me. In some cases, I could name to you, where a native writer has ventured on the most harmless and good-humored illustrations of our vices or defects, it has been found necessary to announce, that in a second edition the passage has been expunged, or altered, or explained away, or patched into praise.

There is a story in Santiago de Chile of a young American scholar who spent some time there studying localisms. When he returned to New York he ventured to publish honest but rather severe criticisms of society, as he saw it, in that most aristocratic of South American republics. As a result, the university from which he came received a bad name in Chile and his visit is held in such unpleasant memory that his welcome, were he to return there, would be far from friendly. This seems narrow-minded and perverse, but is exactly the way we felt not long ago toward foreigners who spent a few months in the states and wrote, for the benefit of the European public, sincere but caustic criticisms. American sensitiveness became a byword in Europe. Possibly it is growing less with us. However that may be, South American sensitiveness is no keener to-day than ours was fifty years since.

It is particularly important that we should realize that the political conditions of the larger republics are very much more stable than our newspaper- and novel-reading public are aware of. Lynchings are unheard of. Serious riots, such as some of our largest American cities have seen within the past generation, are no more common with them than with us. It is true that the Latin temperament finds it much more difficult to bow to the majesty of the law and to yield gracefully to governmental decrees than the more phlegmatic Teuton or Anglo-Saxon. But the revolutions and riots that Paris has witnessed during the past century have not kept us from a serious effort to increase our business with France. The occasional political riot that takes place, of no more significance than the riots caused by strikers with which we are all too familiar at home, is no reason why we should be afraid to endeavor to capture the South American market.

Climatic conditions and difficulties of rapid transportation have had much to do with the backwardness of the South American republics. With the progress of science, the great increase in transportation facilities and the war that is being successfully waged against tropical diseases, a change is coming about which we must be ready to meet.

There is not the slightest question that there is a great opportunity awaiting the American manufacturer and exporter when he is willing

to grasp it with intelligent persistence and determination. South America is ready to take American goods in very large quantities as soon as we are ready to take time to give attention to her needs. As Mr. Lincoln Hutchinson aptly says:

> There is no quick and easy remedy; money must be spent, thoroughly equipped export managers must be employed, export houses specializing on South American trade must be established, efficient travelers must be sent out, technical experts employed, agencies established, credits be given, minutiæ of orders attended to, and, above all, trade connections adhered to in spite of allurements of the home market, if we would succeed in the face of our competitors. Halfway measures can accomplish but little, and that only temporary.

Germany teaches her young business men Spanish or Portuguese and sends them out to learn conditions in the field. American universities long ago learned the advantage of adopting Germany's thorough-going methods of scientific research. American business men have hitherto failed to realize the importance of adopting Germany's thorough-going methods of developing foreign commerce. It is high time that they took a leaf out of the experience of the "unpractical" universities.

Finally, a word of caution to those in search of information regarding the history, politics or geography of South America. The most unfortunate result of the seven centuries during which Arab, Moorish or Mohammedan rule dominated a part or the whole of the Spanish peninsula, is the truly Oriental attitude which the Spaniard and the Spanish American maintains towards reliable information, or what we call "facts." The student of the East realizes that orientals, including Turks and celestials, have no sense of the importance of agreeing with fact. They have, furthermore, a great abhorence of a vacuum. If they do not know the reply to a question they answer at random, preferring anything to the admission of ignorance. If they do know, and have no interest in substituting something else for what they know, they give the facts. When they have no facts they give something else. They not only deceive the questioner, they actually deceive themselves. The same thing is true to a certain degree in South Americans. Sometimes I have thought they were actually too polite to say "I don't know."

In South America as in the East it is of primary importance to reach the men who know and to pay no attention to any one else. No one really knows, who is not actually on the spot, in contact with the facts. The prudent observer must avoid all evidence that is not first hand and derived from a trustworthy source.

I do not bring this as a charge against the South Americans. I state it as a condition which I have found to be nearly universally true. So far as the South Americans are concerned it is an inherited trait and one which they are endeavoring to overcome. They are not to be blamed for having it, any more than we are to be blamed for having inherited traits from our Anglo-Saxon ancestors which are unpleasant to

our Latin neighbors and for which they have to make allowance in dealing with us.

In offering these adverse criticisms of the South American as he appears to me to-day, I must beg not to be misunderstood. There are naturally many exceptions to the rule. I know personally many individuals that do not have any of the characteristics here attributed to South Americans in general. I have in mind one South American, a resident of a much despised republic, whose ancestors fought in one of the great battles of the Wars of Independence, who has as much push and energy as a veritable New York captain of industry. He has promoted a number of successful industrial enterprises. He keeps up with the times; he meddles not in politics; he enjoys such sports as hunting with hounds and riding across country. The difference between him and the New Yorker is that he speaks three or four languages where the New Yorker only speaks one or two and he has sense enough to take many holidays in the year where the New Yorker takes but few. I know another, a cultured young Chilean lawyer who gives dinner parties where the food is as good, the manners as refined, the conversation as brilliant and the intellectual enjoyment as keen as any given anywhere. He, too, speaks four languages fluently and could put to shame the average New York lawyer of his own age in the variety of topics upon which he is able to converse, not only at his ease but brilliantly and with flashes of keen wit. I know another, a distinguished historian, who has been described by a well-known American librarian, himself the member of half a dozen learned societies, as the "most scholarly and most productive" bibliographer in either North or South America.

Such men are worth cultivating. We have much to learn from them, especially of the value of polite language and courteous intercourse. At close range we may dislike some of their manners and customs, but not any more so than European critics disliked ours half a century ago. And not any more so, be it remembered, than the South American dislikes ours at the present day.

The South Americans of to-day have so many of the faults of the Americans of yesterday that all *our* dealings with them should be marked by appreciative understanding and large-minded charity. Any feeling of superiority, like that "certain condescension" which we have noted (and hated) in foreigners, will only make our task the harder, and international goodwill more difficult to achieve.

WHEN DOES A FOOD BECOME A LUXURY?

By Professor E. H. S. BAILEY
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IN the rapid expansion which is taking place in this country, and in attempting to adjust ourselves to these changed conditions, and to the higher price of foodstuffs, there is danger that we forget to differentiate as carefully as we formerly did, between a nutritious food, which is purchased for its food value, and other products, also good enough as foods, but which are sold at prices which bring them within the domain of luxuries.

In buying delicately flavored candies or chocolates at from 40 to 80 cents per pound, although it is recognized, by those who think about it, that the chocolate and sugar are excellent food material, no one buys such things *as* food. They are purchased as luxuries pure and simple, because their flavor pleases the palate. Chocolate and sugar are also sold as food, or to be used as a constituent of foods, at a price so low that they can properly be used in the preparation of foods and beverages. In this case their food value is more closely proportionate to their cost.

Although a definition is in some cases a stumbling block, we venture to say that, in case of foods, a luxury is a substance that may have some nutritive value, but which has a low food value in proportion to the cost while, on the other hand, a food has, or should have, a comparatively high food value in proportion to its cost.

Some foods are expensive on account of their rarity or because they are out of season, some because of the cost of the original material from which they are made, some because they are brought from such a distance that the transportation charges are high, and others on account of the expense attending the manufacture.

In general, manufactured foods cost more than those upon which but little labor has been bestowed to prepare them for market. This is well illustrated in the case of ordinary granulated sugar which frequently retails at five cents per pound, while (although often made from the same "stock") "cube" sugar, which has been sawn into blocks, and "powdered" sugar, which has been ground and perhaps bolted, sells at ten cents per pound. The original materials in a five-cent loaf of bread would probably not cost three cents, yet we recognize that to make the bread and bake it and deliver it to the consumer costs some-

thing, and the manufacturer is entitled to a fair profit. That profit can be saved by the consumer if he does his own manufacturing and makes his bread at home, but that means an expenditure of labor and fuel.

There are many vegetables and fruits which, on account of containing from 30 to 90 per cent. of water, have a comparatively low food value, and seem to be expensive foods. Some of them are, but on account of the vegetable acids present, or because they dilute the more concentrated foods, or are stimulating to the appetite from their variety and agreeable taste, it is everywhere conceded that they are valuable additions to the diet. If fruits are out of season and consequently expensive, the ordinary purchaser is content to wait until they are abundant and cheap. If he pays a high price for the fruits, he immediately recognizes that they are to be classed as luxuries.

Although it may with reason be said that the cold-storage industry has afforded an opportunity to hold back from market certain perishable food products, and thus keep the price up to a figure which will insure a handsome profit, this practise has extended very greatly the season in which fruits and similar products may be offered for general consumption, and in many cases it has withdrawn them from the class of luxuries.

Game and expensive fish the ordinary consumer is not tempted to buy, but when it is a question of the "cut" of beef or mutton, he sometimes says, "the best is none too good for my family," and so buys the choicest cuts, not recognizing that others of less delicate flavor would afford the same nourishment per pound, and would if properly cooked and served be appetizing and in every way satisfactory. The sirloin may be a luxury, but the consumer does not recognize it as such and consequently spends more of his wages than he can afford upon this form of nitrogenous food.

The rapid change that is taking place in the dietary of the American people, and the necessity for doing without servants, because efficient help can not be obtained, has but confirmed the tendency in every household to allow the food manufacturer to prepare the food, and thus diminish as much as possible the labor of the household. This movement applies to all articles of household use, so that all possible labor is now done outside the home. It would be useless to attempt to stem this tide, but something may be done to direct it so that it will not entirely exhaust the family resources.

The manufacturer prepares the food from more or less satisfactory "stock," and within recent years, with fair attention to the sanitary condition of the factory. It may be packed in cans or packages or boxes or cartons, and if the package is tastily put up, and the contents have an agreeable taste, the consumer does not stop to inquire whether

he is getting his money's worth or not—whether his pounds are sixteen ounces or only ten; whether he is paying at the rate of five or twenty-five cents per pound for a simple, ordinary, nutritious food. The list of foods sold in packages is constantly increasing. It includes fruits, pickles, vegetables, crackers, cakes, cereals, syrups, meats, fish, vinegar, spices, milk, cheese, butter, jams, jellies and even dried eggs. The great advantage, which all will admit, is that the package protects the food from dust and dirt and possible infection. The disadvantage is the greatly increased cost over the bulk articles.

Until the present food laws and the "weight and measure" laws were enacted, the consumer had not perhaps noticed that the "carton" had taken the place of the pound, and that this had shrunken in weight with each passing season. When the housekeeper, who was hard pressed to make her scanty allowance carry her through the week, expostulated with the grocer, in regard to the weight of his "pound" of butter, he simply said "That is the way we buy it; we do not sell the package for a pound; nobody is cheated." Decidedly some one was cheated—the consumer of course. The small housekeeper buys a bottle of vinegar for 15 cents or at the rate of 60 cents per gallon for vinegar selling in bulk at 25 or 30 cents per gallon.

One of the most conspicuous illustrations of the tendency to allow the manufacturer to reap, to say the least, a large profit, because the consumer wants to buy his food "ready prepared," is the fad of making the breakfast to a great extent of the newly invented "breakfast cereals." A few years ago the people did not know the meaning of these words, and now they are common in the most modest bill of fare.

Since these foods are made mostly from wheat, corn and oats, it is absurd to suppose that the claims of some of the manufacturers are true, when they say that these foods are in every way better than the original grains from which they are made—in fact that the process of manufacturing is a proteid-concentrating process. Analysis has shown that the amount of so-called "predigested" or "malted" material in these foods is small at most, and aside from the dextrin which is formed largely by dry heat just as bread is toasted or potatoes are browned in frying, these "malted" foods are little better than crackers or bread. It is a question, anyway, whether the normal stomach welcomes the appearance of predigested food; it is provided by nature with "apparatus and chemicals" necessary for the digestion of food, and why should the work be taken away from it?

Dismissing then the claim that these prepared foods are so much better than simply ground and partially bolted cereals, what do we pay for the finished product per pound? Are these cereals luxuries?

From the Bulletin of the Maine Agricultural Experiment Station for 1906 we quote the following cost in cents per pound for some of

these foods: Quaker oats, 3.1 cents; Nichol's pearl hominy, 4.5; Cream of Wheat, 8.8; Grape Nuts, 14.6; Shredded Whole Wheat, 15; Force, 16.5; Flaked Rice, 18.2; Granula, 27.2. To this may be added the cost of some other brands, as Quaker Corn Flakes, 13.3; Kellogg's Corn Flakes, 13.3; Maple Corn Flakes, 14.5; Post Toasties, 14.5; Grape Sugar Flakes, 17.8; Malta Vita, 18.4; Sugar Corn Flakes, 20; Holland Rusk, 22.8; Puffed Wheat, 29.1 cents. At this rate *a bushel of wheat* which might be originally worth $1.00 would, when made into a breakfast food, cost the housekeeper from $5.00 to $12.00, calculating that 75 per cent. of the grain is available as food, as is the case in making wheat flour. Oatmeal in bulk sells at five cents a pound, and simple preparations of the other grains at from five to seven cents.

These are a few of the illustrations to show "where the money goes," or at least some of it, expended in the ordinary household. Some of us are living on the luxuries of the market, and use them as food to furnish the proteids and carbohydrates and fat for daily consumption. Instead of using the oak and maple and pine for fuel, we are feeding the fire with mahogany, and circassian walnut and rare imported woods.

THE PALEONTOLOGIC RECORD

THE BIRTHPLACE OF MAN

By Professor S. W. WILLISTON
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VARIOUS writers, from Le Conte to Smith Woodward, have spoken of critical or rhythmical periods in evolution, periods when evolutionary forces have acted more vigorously than at others, with intervals of relative quiescence. What these forces are and have been we are not yet sure, whether extrinsic, that is, environmental or Lamarckian, or intrinsic, that is, orthogenetic, teleological or what not. Perhaps we shall sometime be more certain of the basal causes of evolution, for the paleontologist at least is not satisfied with the crass ignorance of our Weismannian friends who impute the beginning of all things to mere chance. Perhaps when we do know these fundamental causes we shall understand better why evolution has been rhythmical, if such was really the case, as some of us believe with Woodward.

But, whether there have been internal forces which have had chiefly to do with the rhythm of evolution, or whether such critical periods in the evolution of organic life have been due solely to the larger cosmic forces, I think we shall all admit that there have been critical places of organic evolution, places upon the earth where evolution has advanced with more rapid pace than in others, places perhaps where environmental conditions have conspired to hasten the development of life, or of particular groups, classes or kingdoms of life.

Such a critical period, at least for the higher organisms, it seems to me, was the early Pliocene; such a critical place was central Asia; and both together resulted in the birth of man.

It is a curious fact that nearly all our domestic animals had their origin in Asia. It is also a curious fact that the domestic animals are, almost without exception, the crowning ends of their respective lines of descent, the most highly specialized of their kinds. The genus *Bos,* the most highly developed of the even-toed ungulates began, to the best of our present knowledge, in the Lower Pliocene of India. And its four distinctive types likewise first appeared there: the *Bubalus* group, including the domestic buffalo of India, and its untamable kin of Africa; the group that is represented by the domesticated humped oxen of India and their wild relatives of Africa; the bison strain which spread in Pleistocene times almost to the remote corners of the earth;

and the true oxen, the most useful of all creatures to man, which spread to Europe as *Bos primigenius,* the ancestor of *Bos taurus.*

The sheep also found their expression point in India, and their home to-day is central Asia. So too the domestic goat yet lives wild in western Asia, a less plastic type, but purely Asiatic in origin. Indeed, of the whole family of Bovidæ, Asia was the origin and dispersal center, and it is a curious fact that it still remains the home of the higher types while others of lower degree have wandered afar to find their homes in Africa, Europe and America. The camelids after long ages of exclusive development in North America migrated to Asia to find their highest evolution in the true camels, the highest and probably final stage in the evolution of the family, while their kin, of lower degree, went southward to terminate in the llama and alpaca, the only mammals among all man's servants which we can say with tolerable certainty have been entirely beyond the influence, direct or indirect, of Asiatic environment. The reindeer, the highest of all the cervid family, doubtless arose in northern Asia; certainly its home is in part there, though some of its early kin migrated to America and have left their descendants in the caribous. And India was the birthplace, as it is the home, of the pig, whence came originally our domesticated swine. Whether or not we give to *Sus* the highest place among the non-ruminant, even-toed ungulate mammals, or to the Babirussa, matters not, for both are of Asiatic origin.

Of the odd-toed ungulates our domestic horse, *Equus caballus,* stands on the very summit; and *Equus caballus* arose in Asia, where its ancestors yet have their wild progeny. And I believe that eventually we must give to Asia the honor of the birthplace of the genus itself. And the next lower type of the Equidæ, the asses, are of Asiatic ancestry, though our domestic species comes from Arabia and Africa, while the most primitive of the horses yet living found their refuge in Africa.

Southern or central Asia was the birthplace in early Pliocene times of the elephants, and was their dispersal center; and, in *Elephas indicus,* the only domesticated species, we have the last and highest stage in the evolution of the Proboscidea, and, as is the case with the cape buffalo, the zebras, wart hogs and others, we find in Africa their only living kin, of more primitive form and untamable.

Of all the great order of Carnivora the genus *Felis* admittedly occupies the highest place. The home of the cats is southern Asia and there doubtless was their birthplace and the center of their dispersal. The known paleontological record of the true cats is very meager indeed, and doubtless always will be till we know more of the Pliocene and Pleistocene faunas of Asia. Two of the domesticated cats, the Siamese and the cheetah, are of immediate Asiatic origin, and our fire-

side pet, while coming from northern Africa, doubtless arose from Asiatic forebears in Pliocene or Pleistocene times. What the origin of the various strains of dogs was we know not, though the wild forms most nearly allied are living in Asia to-day, and the greyhound and mastiff almost surely were domesticated in Africa thousands of years ago. I believe that we may safely give to Asia the honor of the birthplace of most of the domesticated species in Pliocene or Pleistocene times.

Nor does it seem that this remarkable evolutional acceleration during Pliocene times in central Asia was confined to the mammals alone. The ostrich, the highest type of ratite birds, arose in central Asia. The jungle fowl, the highest of the gallinaceous birds and the ancestral stock of our most valued domestic fowls, arose in India and is still at home there. The peacock is exclusively Asiatic; the gray goose, the parent of our domestic geese, has its home in part at least in Asia; and the same may be said of the ancestors of the domestic doves; while the domestic duck may have originated there for aught we yet know. The guinea fowls only are exclusively African, and the turkey American.

Of the reptiles I will venture to say less. But is it not a significant fact that the highest specialization of the reptilian class appeared during Pliocene times in the gigantic extinct gavials of central Asia? Certainly the cobra is entitled to a high but unenviable distinction among the snakes. And *Megalobatrachus,* the largest of all recent amphibians, lives in Japan and China. Finally, of the domestic plants by far the majority come directly or indirectly from the Asiatic flora.

Have all these and doubtless many other facts of their kind no significance? Has man been an exception among so many branches of vertebrate evolution? The common inference has been that so many of our domesticated animals and plants come from India because man first reached civilization there, but the inference is, I believe, quite unjustifiable. Man was born and attained elemental civilization in Asia because there was the place of all others upon the earth where evolution in general of organic life reached its highest development in late Cenozoic times. No mammals and few other creatures have been domesticated by man in thousands of years, for the simple reason that he had eliminated all but the most advanced and most adaptable long before, and none were left to compete with them.

That man originated in the western continent is quite impossible. There is not a particle of evidence in support of such an hypothesis, for there is no evidence that either man or any of his ancestry ever inhabited the western continent till late in Pleistocene times. Indeed, so far as North America is concerned, there is much to justify the assertion that the Pliocene and Pleistocene were a period of evolutional depression here, of relative quiescence when the rhinoceroses, tapirs,

and later the camels and horses, found conditions uncongenial and migrated to Asia, a more favored region.

It has often been assumed that man must have originated in a warm or tropical climate, to account for the loss of his hairy covering. But I quite agree with Dr. Matthew, that the loss of hair is almost conclusive evidence of his origin in a temperate or cold climate where he found clothing necessary to protect himself from the inclemencies of the weather. We know of no mammals or birds losing their pelage or plumage because of tropical conditions, though some may have lost their hair because of vermin.

Taking all these facts and conclusions into consideration it seems to me that such evidence as paleontology can at the present time offer points toward central Asia as the birthplace of *Homo,* and that the time of his origin, as a family, was late Miocene or early Pliocene. If *Pithecanthropus* be really a true hominid, then we already have evidence of his origin in the Asiatic region. Be it as it may, I confidently believe that within a very few years the discovery of indubitable links in man's ancestry will be made in central Asia, in China or northern India. Perhaps to no region of the world does the paleontologist look with more eager expectation for the solution of many profound problems in the phylogenies and migrations of the mammals than to central and eastern Asia. That there are remains of many extinct vertebrates awaiting discovery there in the late Tertiary and Pleistocene deposits has been made evident by the many fragments brought to light by explorers and travelers.

A field second to none other in the importance and richness of the results to be expected awaits the paleontologist in Asia.

THE RELATION OF PALEONTOLOGY TO THE HISTORY OF MAN, WITH PARTICULAR REFERENCE TO THE AMERICAN PROBLEM

By Professor JOHN C. MERRIAM
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CONSIDERED in its broadest aspect, the most important relation of paleontology to the study of man concerns the support which it gives to the general theory of evolution of the organic world. If it be held that we have reason to believe man, with all his highest qualities, a product of evolution out of so-called lower animal types, then it becomes necessary to have a full knowledge of the history of man and of the forms preceding him, in order to understand the origin and the true nature of man's fundamental characteristics as they exist to-day. On the other hand, if there is reason to believe that man as

represented in his highest attributes is entirely apart from nature, the importance of paleontology, as offering a part of the explanation of the fundamental characteristics of man, is very greatly diminished. The value of paleontology would then lie largely in an interpretation of the setting or environment in which man is developing.

With these considerations in mind, it appears of the greatest importance for us to obtain as full a history of the organic world, and as satisfactory an interpretation of the processes therein concerned, as it is possible to secure. Particularly is it desirable to have before us a clear statement of that portion of the paleontological record which leads from the higher vertebrates through the primate division to man.

One of the important phases of general paleontological work which must receive special attention is the early history of the primate order with particular reference to the development of those characteristics which are most prominent in the human family. We have, as yet, accumulated too little evidence in this field. Among the characters which must be followed would be (1) extraordinary brain development, (2) the tendency to development of an upright position, (3) the freeing of the anterior limbs from the work of locomotion and the development in them of extraordinary adaptability. Whatever other interests one may have, there is certainly no more alluring problem than tracing from the primitive mammalia into the early primate those peculiar characters through which later on primitive man began the process of making nature subservient to himself. We may never know whether the brain actually grew large first and requisitioned the hands, so that the animal became bipedal and therefore finally erect in position, or whether a tendency to erect position was directed by the frequent assuming of a vertical position in a tree-climbing ancestor; but it is not beyond reason to presume that a thoroughly satisfactory paleontological record might give us an explanation of the origin of these characters.

The later primate history, or that which leads directly to the human type, is also unfortunately incomplete, though most remarkable advances have been made in the last few years. More missing links have already been furnished than science was supposed to require a few decades ago, but we can hardly be said to have one tenth of the material that it is desirable to have in order to show the transition from anthropoid to human, or from pithecanthropoid to the type of Spy or Neanderthal. European paleontologists are at the present time making rapid strides in filling the gaps of that portion of our ancestral chain which falls in the Quaternary system, and we may look for other important discoveries within the next decade.

It is to be presumed that the greater part of the work on the late Tertiary and Quaternary history of man will be carried on in the old world. The writer sees no reason why in this important work Amer-

ican paleontologists should not interest themselves to some extent in investigations now in progress in Europe and Asia, just as American archeologists have contributed to the success of work on the later history of man. Whether American paleontologsits, working in their own field, are to have a part in interpreting the Pleistocene history of man is a burning question at the present time.

Whether we find that man was in North America in Pleistocene time or not, it is certainly true that one of the most important problems in the general history of the human race concerns the date of occupation of the western hemisphere by the human family. Discussion of the numerous finds reported to represent Pleistocene man in North America are too well known to every one to require particular mention. It should only be noted in passing, that as yet no specimens representing either skeletal remains or implements of man found in North America are generally recognized by geologists and paleontologists as of Pleistocene age. A careful search through the literature, and the investigation of many of the actual occurrences, lead the writer to the conclusion that we have, as yet, nothing in North America which can be considered as unquestionably representing Pleistocene man.

Also in South America there has been serious discussion of many interesting finds. The evidence on the whole seems to be more distinctly in favor of Pleistocene occupation there than is the case in North America. The discoveries made in recent years in the cave at Last Hope Inlet, and the numerous remains found in the Pampean formation at levels very far below the surface, seem difficult to interpret excepting on the supposition that man was present in South America before the beginning of the recent epoch.

It is to be presumed that any occupation of South America would necessarily be through migration by way of the northern continent, and proof of the presence of man in South America in Pleistocene time would be tantamount to proof that he was in North America at least as early. This suggestion does not, of course, take into account the theories of Ameghino to the effect that man is possibly derived from some of the South American monkey forms. Another suggestion made by Ameghino would give us an immigration of old world forms, possibly with ancestral man, coming into the southern continent in comparatively late time, by some other route than North America.

In the consideration of man's history in America, it is particularly important to notice the probable relation of migrations of the human family to migrations of other groups of mammals. The presumption is that the migrations of primitive man were caused or occasioned largely by influences of the same sort as have produced the spreading out or migration of many other mammalian types. It becomes then particularly necessary to discover exactly when the more recent migra-

tions of mammals into the North American continent have taken place, and, so far as possible, the exact routes of migration. This problem is in a large part paleontological, requiring for its interpretation a satisfactory account of the paleontology of vertebrates, invertebrates and plants of North America and of Asia, with particular reference to the relations of adjacent areas. We must also have, associated with this information, a full statement of the crustal movements in these regions as interpreted by the stratigraphic geologists and the physiographers.

Through the accumulated efforts of paleontologists in this country particularly, we have already a considerable mass of evidence bearing on the general relationships of the faunas of North America and Asia in comparatively recent geological time, but the detail of the problem is, as yet, scarcely indicated. Particularly for Pleistocene and Pliocene time our knowledge of the faunal succession is exceedingly meager, and we can scarcely expect to know anything satisfactorily until the Pleistocene mammalian paleontology of America has been worked out in detail. This work must be followed or accompanied by similar studies of the mammalian faunas of western and southern Asia. When this is completed we shall know the time of the various migratory movements, the nature of the faunas which migrated, the character of the land areas over which they have passed, and the climatic conditions which obtained along the routes of migration. The presumption is, that when this is done we shall have actual evidence of the time of man's occupation of North America.

Viewed in the large, and without regard to the detail which has just been indicated, it seems possible to present several reasonable conclusions with reference to the probable period of migration of man to America. It is shown by study of a map of linguistic stocks of the western hemisphere that the northern and southern continents taken together may be divided into between one hundred and two hundred provinces, based on the number of stocks represented. These languages vary greatly in their structure, and are not similar to the languages of other parts of the world. There is every reason to believe that a large percentage of them have been developed by linguistic differentiation which occurred since man first occupied this continent, and that measured in years the time required for this differentiation has been long. On the other hand, considering the American continent as a whole, we find that the greatly differing physical environments are not reflected to any extent in different physical types of people occupying this region. That the human family is not exempt from physical differentiation, such as is almost universally indicated in mammals which have for some time been distributed over large areas with varying environments, is clearly shown by the map of the old world. In that region the human race is known to have been spread over a wide

area for a long period, and we find several greatly differing human physical stocks in different geographic regions, just as we find differing stocks of mammals and birds.

With the lack of physical diversity among the people of the western hemisphere, there is also noticeable a resemblance of the whole group to the people of the adjacent region of Asia. Judged by the standards of differentiation which we obtain through a study of the history of geographical distribution of other mammalian groups, we have every reason to think that the people of America are immigrants who came from the Asiatic region and spread themselves over America after the period of the first great physical differentiation of the race, and so recently that a second stage of physical differentiation has not yet had time to develop. On the other hand, the time measured in years has been long enough so that linguistic differentiation could take place.

Inasmuch as a large part of human history falls within the Quaternary period, the question naturally arises as to whether the principal migrations of man to the American continent occurred *before, during* or *after* the Glacial epoch.

As primates are naturally animals of a warm or temperate zone, it is hardly to be presumed that primitive man came to America *during* the ice age, though there is a possibility of immigration in some of the interglacial epochs. Judging from what is suggested through study of physical differentiation, it appears improbable that man came over as early as the epoch preceding the ice age. In other groups of animals spread over large areas, marked physical differentiation has ordinarily taken place in a space of time comparable to the Glacial epoch. Had man been present in America during this long period, widely differing physical types would almost certainly have developed. On the whole it seems most probable that he arrived after the end of the last division of glacial time, or very near the beginning of the present epoch. Whether his arrival is shown to have occurred just before or just after the beginning of this epoch remains to be determined.

In conclusion it seems desirable to call the attention of paleontologists once more to the important part which their work must play in obtaining the information which we need with reference to the history of man and his antecedents. Only a small beginning has been made, and the results which must come are of great importance in the large problem of man's relation to nature. It is necessary that paleontologists keep the subject before them, in order to make certain that all information bearing upon it may be recognized as it becomes available, and be given its proper place in relation to other evidence now at hand.

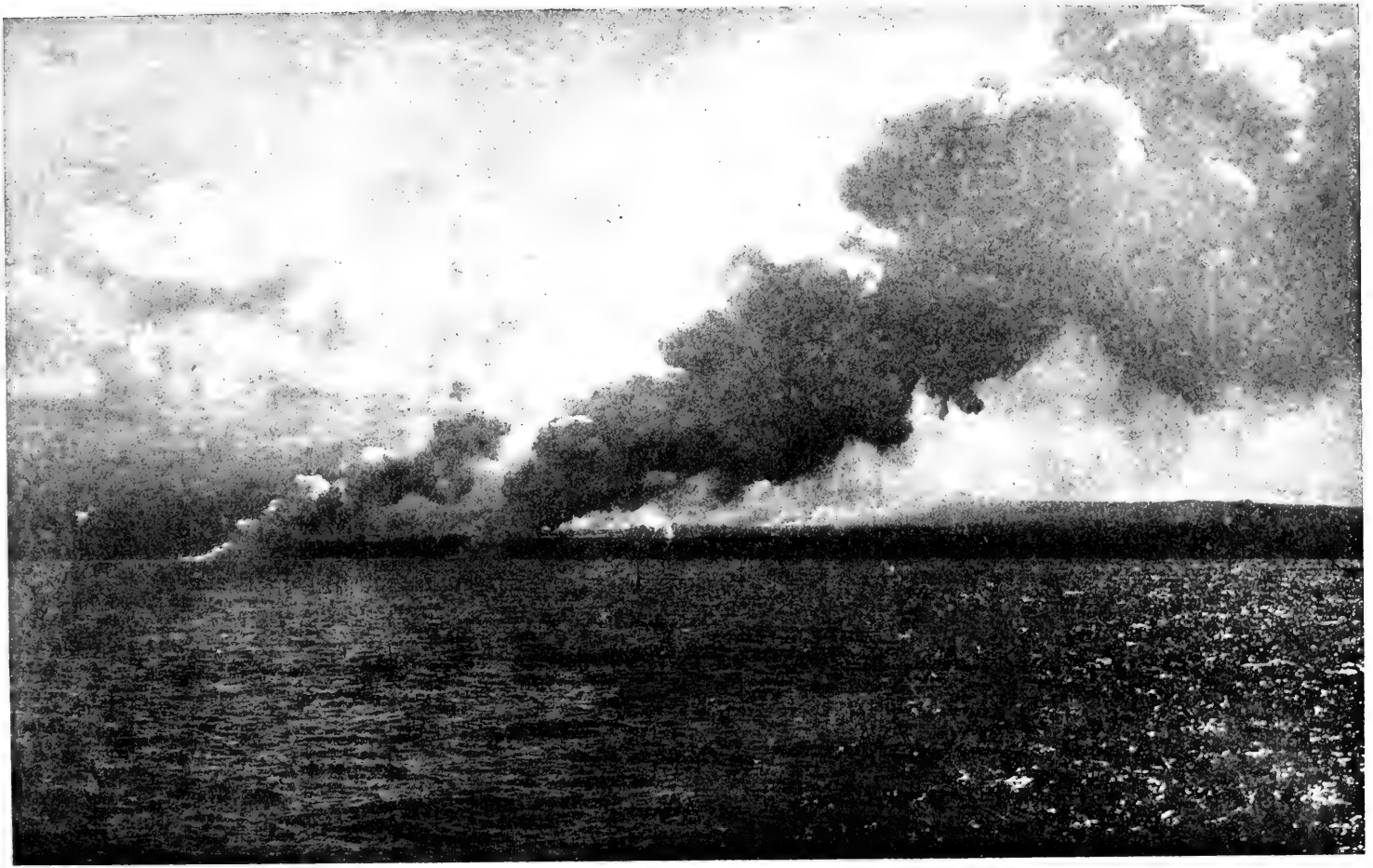


FIG. 1. SAVAII VIEWED FROM THE SEA.

TWO ACTIVE VOLCANOES OF THE SOUTH SEAS

By Professor HENRY E. CRAMPTON

BARNARD COLLEGE, COLUMBIA UNIVERSITY, AND THE AMERICAN MUSEUM OF NATURAL HISTORY

IN the course of a fourth journey among the islands of the Pacific Ocean, during the year 1909, the rare opportunity was presented of making an ascent of the remarkably active volcano formed about five years ago on the island of Savaii, the largest member of the Samoan group. In addition, during a short stay in the Hawaiian Islands, a visit was made to Kilauea, a volcano which in contrast with the former, has a long geological history, for records of its intermittent periods of activity cover more than a century. It is the purpose of the present article to give a short general description of these two volcanoes.

Under any circumstances such works of nature would arouse the interest of a student of natural phenomena; but in my own case the opportunity to study them was valuable for additional reasons. My investigations of the distribution and evolution of the land snails of Polynesia demanded a thorough exploration of volcanic islands of greater age, islands that for many centuries have been sculptured by the elements so as to display alternating ridges and valleys radiating from their high central peaks. Tahiti is perhaps the most beautiful example of such an island. One finds that the several islands of the Pacific groups are of various geological ages, and consequently exhibit different degrees of weathering. They thus constitute a series showing how ancient rugged islands like Tahiti and Moorea have been derived from newly formed volcanic mountains like those of the Hawaiian and other groups, which possess relatively even sides of lava fields unfurrowed by erosion. Furthermore the various islands scattered throughout the vast areas of the Pacific Ocean are interesting to the naturalist because of the evidences they give of great changes in the level of the ocean bed, and also on account of the rôle played by corals in the construction of many types of islands. With few exceptions the islands occur in groups or chains suggesting the conclusion that they are the peaks of a range of mountains formerly connected by lowlands but now separated as the result of a subsidence of the ocean's floor. Every one is familiar with the theory that a coral atoll, consisting of a living reef bearing a more or less extensive series of coral islets, is built upon such a volcanic peak, which, according to Darwin and Dana, has been withdrawn below the water's level and overgrown by coral as it slowly subsided. It may be, as Agassiz contends, that a coral

FIG. 2. WESTERN LIMIT OF THE LAVA FIELD ALONG THE SHORE.

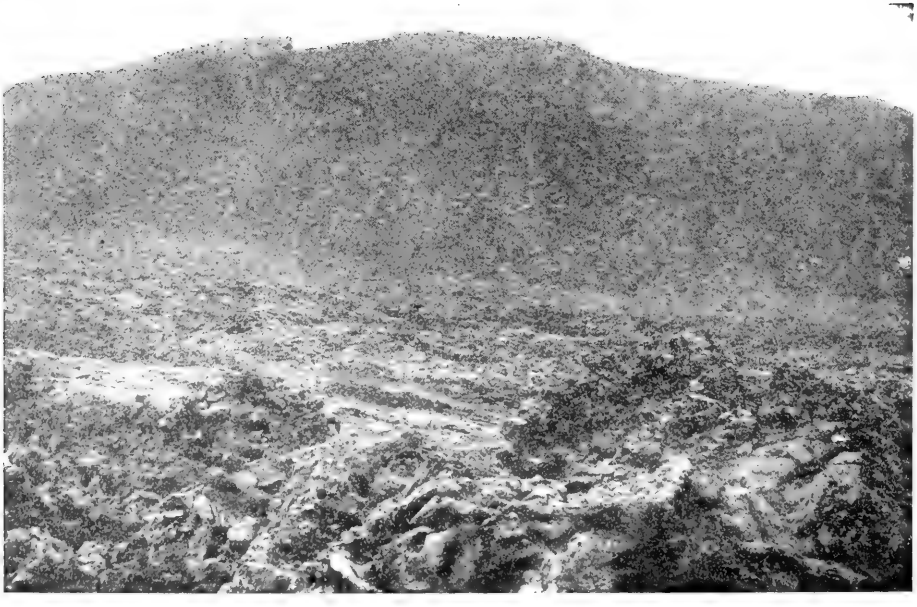


FIG. 3. THE CONE OF SAVAII.
The cone is 400 feet from base to crest.

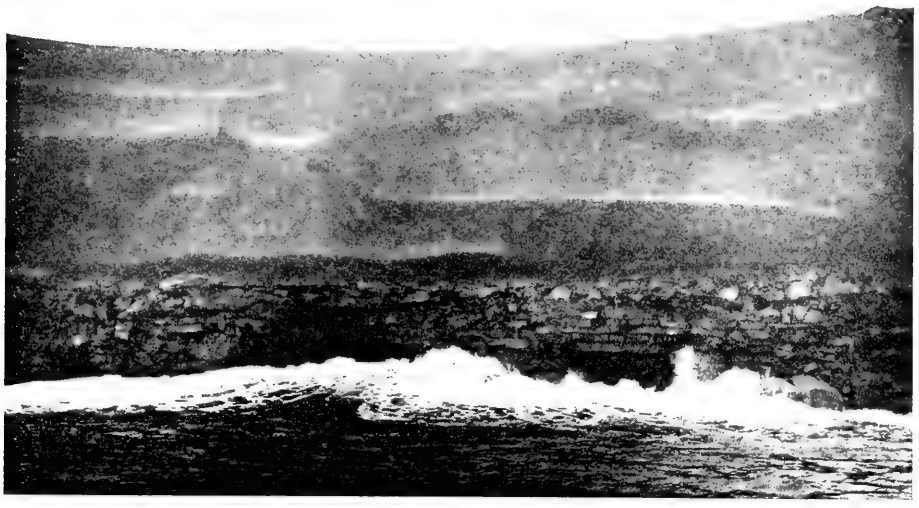


FIG. 4. SEA WALL NEAR THE CASCADES OF MOLTEN LAVA.
Cinders and lava, in superimposed layers.

FIG. 5. RUINS OF STONE HOUSES INUNDATED BY LAVA.

FIG. 6. CRATER MARGIN, SAVAII, FROM THE SEAWARD SIDE.

atoll is built upon a submarine volcanic mountain upheaved from the ocean's floor; but in either case the relation between coral reefs and volcanic peaks is one that possesses a real importance for the zoologist.

The two volcanoes of Savaii and Kilauea occur in island groups that are in every way typical of the so-called "high" islands of the Pacific Ocean. The Samoan Islands, including Savaii, lie almost on a straight line running nearly east and west. Upon examination they prove to be of various ages, for the westernmost, Savaii, bears the active volcano and displays other indications that it is more recent in origin than its neighbor, Upolu; this island, in its turn, is younger than the more rugged Tutuila and Manua to the east. The Hawaiian Islands, containing Kilauea, also range with some regularity along a line, which in this case runs west-northwest and east-southeast; but one very interesting difference consists in the fact that the newest island, Hawaii, lies at the eastern end of the group, while the relative geological ages of the other islands correspond with their serial geographical order westward to Kauai, the oldest and most sharply sculptured member of the group. In all other essential respects, the Samoan and Hawaiian Islands are closely similar. Our interest centers about the peculiar features of their two active volcanoes, and the ways in which these agree and differ.

The new volcano on the island of Savaii is assuredly the more impressive of the two. Its total mass is great, but this feature is not so striking as its remarkably rapid development in the short period of five years; this development and the continual flow of fiery lava from its vast crater entitle it to supreme place in the array of volcanoes now in activity. It lies about eleven miles back from the coast nearly opposite the middle of the north shore of Savaii, which is roughly rhomboidal in outline and forty miles long. Approaching this part of the island by day, the most striking features of the panorama are the two vast clouds of steam that rise from the places where molten lava pours in cascades into the ocean (Fig. 1). Upon the glistening black slopes beyond, jets of vapor mark the vents in the roofs of the tunnels through which the fluid lava runs upon its seaward journey from the crater; and from the crater itself, two thousand feet above sea level, rises a similar fountain of thin steam that quickly merges with the dense clouds above.

When one looks upon the enormous mass of this new mountain, it seems impossible that five years could be sufficient for its formation, yet this is actually the case. The first crater appeared in August, 1905, upon the floor of a beautiful green valley. As cinders and lava were cast forth, they gradually built up a larger dome and spread out to form the first strata of the great volcanic field. The flow followed the valley

FIG. 7. MAUNA LOA, HAWAII, VIEWED FROM THE SEA.
The even slopes, bearing secondary cones, rise slowly and grandly to a high summit.

FIG. 8. LAVA-FIELD OF THE MAIN CRATER BASIN OF KILAUEA.
The jet of vapor marks the fire-pit of incandescent lava

to the ocean, but as wave after wave of fluid lava or steam-charged ash swept downward, more and more territory was devastated, while the lava, already cooled to form ridges and hillocks, diverted the later lava rivers into irregular and wider-spreading channels. Reaching the ocean, the molten rock poured into the depths of the sea over the coral reef, building ever outward, at the same time that it followed the reef and shore so as to spread laterally over a sector of the island with a shoreward arc of five miles. Naturally the seaward wall of the whole lava field is highest near its center (Fig. 4) where it measures eighty or ninety feet. This wall displays a regular series of strata of prismatic blocks or tables, formed by the cooling of successive sheets of flowing lava. These strata sometimes lie between masses of cinders, showing how the eruptive output varied in character during succeeding weeks and months. Toward either side, the whole field gradually thins out, and at its western edge (Fig. 2) it ends in a series of rough rocky billows, seared and broken by their contraction in cooling. Yet their materials reached this point as red-hot fluid lava, having traversed a route that must have been nearly fifteen miles in length.

As the molten lava swept down the valley and along the strand, its destructive effects were rapid and complete. The wooden huts of the seaside villages were entirely consumed and only where there were walls of coral limestone, like those of the churches and traders' warehouses (Fig. 5), was there anything to withstand the flood of rock. Yet so quickly did the surface of the plastic mass become cool, that the cocoanut and other trees, felled by the burning through of their bases, were rarely consumed.

We began the ascent of the volcano early in the afternoon in order to reach the crater before dusk. Proceeding through the undestroyed woods of a neighboring valley we entered upon the lava field at a point some miles from the coast, thus obviating the necessity of traversing its whole extent from sea to crater. Our natives, bearing food and water, now tied the husks of cocoanuts to their naked feet for protection in walking over the broken lava, and after a final pause for rest, we left the shade and tempered heat of the tropical forest for the open glare of the volcano's slope. Viewed from afar, this slope seems even and smooth, but in reality it is like a tempestuous ocean suddenly arrested in its movements and turned into stone. Here and there wide sheets of lava with corrugated rippling surfaces formed still rivers between massive banks of cinders through which their molten substance had earlier ploughed its way; larger and smaller tables of crust, like broken floes of the Arctic Ocean, were tilted up and piled in strange heaps. And so vitreous was the material of this sea of black broken rock that the light was reflected from millions of crystal surfaces and facets as from so many fragments of ice or glass.

Progress over this field was necessarily slow, but by following the

FIG. 9. "HALEMAUMAU," HOUSE OF PERPETUAL FIRE.

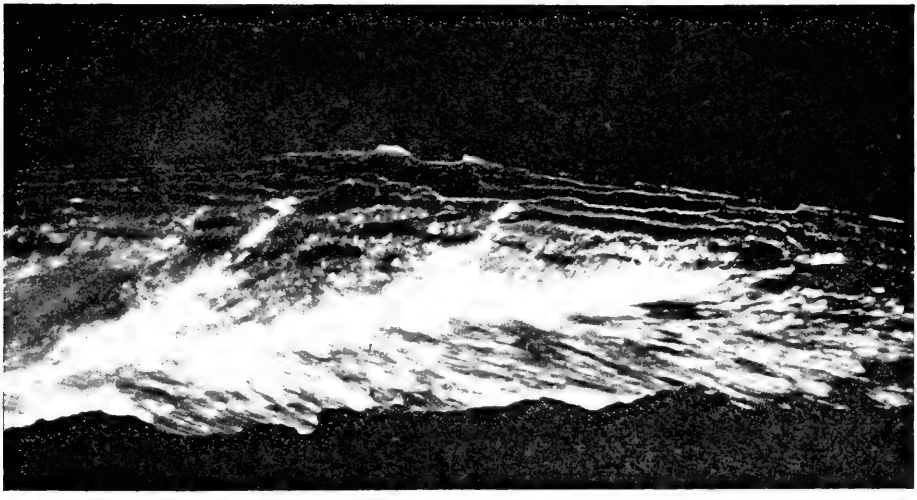


FIG. 10. THE "LAKE OF FIRE" OF KILAUEA AT NIGHT.
The photographic film was exposed four seconds.

general trend of the less broken lava streams, we gradually worked upward and inward toward the main axis of the whole lava mass, indicated by vents which gave egress to steam and gases discharged by fluid lava running through tunnels beneath the surface.

The great crater (Fig. 3) is a perfectly typical cone of cinders and lava, with a height from base to summit of four hundred feet as measured by the aneroid barometer. On three sides it is composed mainly of ashes and pumice, but toward the sea its surface displays smoother areas of rock where the lava formerly welled over the edge before the tunnels were formed by which the discharge now takes place. Large bombs, rounded masses of rock hurled from the crater during some explosive eruption, occur on the slopes, sometimes covered as by a sheet of tar with a later-extruded layer of lava (Fig. 6).

When we stood upon the extreme edge of the jagged margin and looked down upon the immense lake of fiery lava, four hundred feet below, it was hard to realize that the scene was actual and not an imaginary panorama of Dantesque infernal regions. The yawning cavity of the crater extended a full half mile in length, and its width was more than four hundred yards. Almost perpendicular and sometimes undercut, the crater walls dropped hundreds of feet to the lake of molten lava, which was in such violent commotion that it seemed to be liquid flame rather than a mass of fused and fiery rock. At certain places it boiled with greater activity, sending huge jets and fountains high into the air. Its waves moved variously at different times, but ever and again they would surge heavily to dash against the wall where the tunnels opened to give exit for the flow to the ocean. And always from this surface, thin steam-like vapor charged with acid gases swirled upward in the draught caused by the strongly-blowing trade winds, making it excessively unpleasant to look over the edge even from the windward side.

Magnificent though it was by day, the scene at night was far beyond human powers of description. With the darkness, the lake glowed almost as a continuous incandescent mass. Its light was reflected upon the clouds above, making a beacon that we had often seen from a distance of forty miles and which was said to have been visible at a distance of seventy miles during the period of the volcano's greatest activity about two years earlier. Looking seaward, the rosy vapors above the tunnel vents outlined the course of the lava down to the shore of the island where the fire of the final lava cascades gave color to two huge clouds of steam. Again and again through the night we climbed from our camp at the base of the cone to look down upon the fascinating but awful marvel, whose fires illuminated the scene so as to give ample light to guide a way over the broken lava.

Leaving now the volcano of Savaii, which is a veritable classic in its regularity of structure and mode of origin, we pass to the Hawaiian Is-

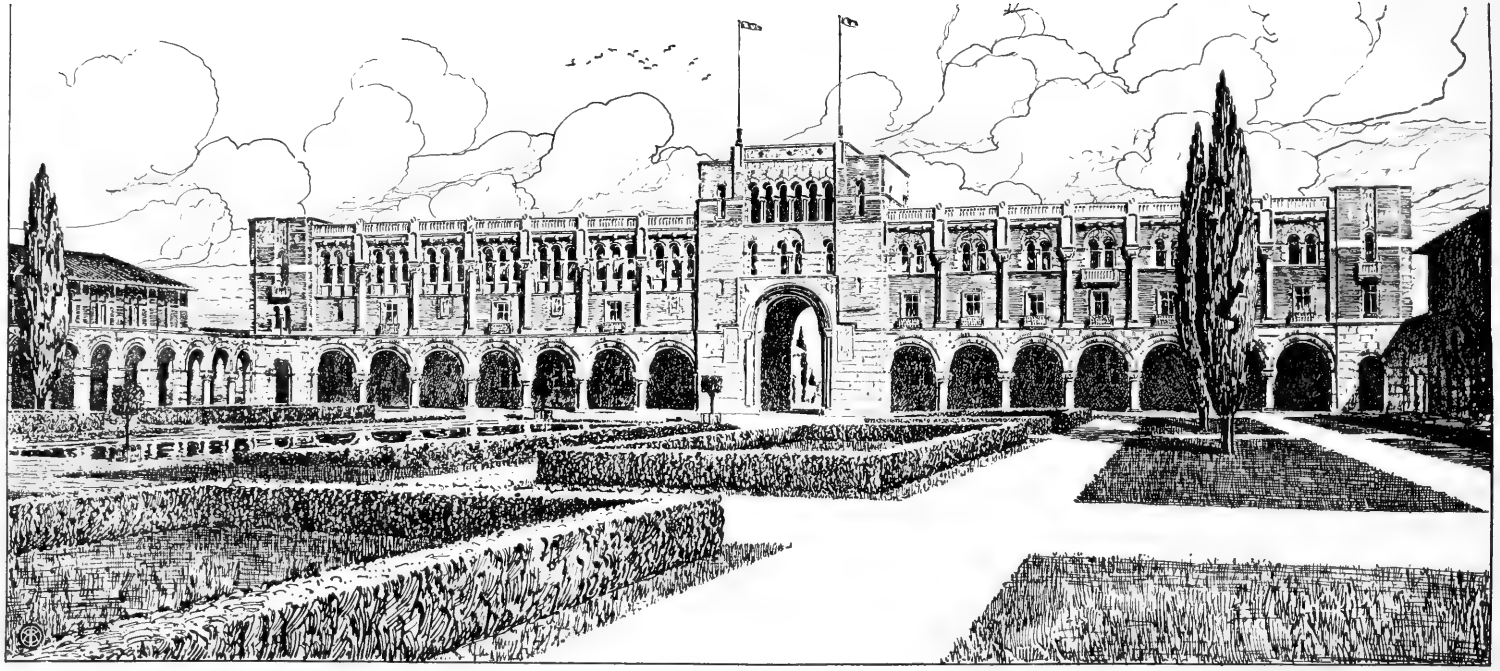
lands and the active volcano of Kilauea that is in many respects quite different from the new one of Samoa. It is an accessory outlet upon the side of the giant volcanic mountain of Mauna Loa, whose main crater at the summit, more than thirteen thousand feet above the sea, is active only at very long intervals. It is a journey of two hundred miles from Honolulu to the island of Hawaii on which Mauna Loa occurs; viewed from the ocean (Fig. 7) the even slopes of the mountain rise slowly and grandly to the high summit, bearing numerous secondary or " parasitic " cones which have been formed by sporadic local eruptions.

The first view of Kilauea itself is somewhat disappointing to one who has recently witnessed the grandeur of the eruption at Savaii, but closer acquaintance reveals many features of great interest. Kilauea lies about four thousand feet above the level of the sea, and is about twenty miles back from the coast. In general structure (Fig. 8) it is a wide shallow basin over three miles in diameter, depressed below the general level of the slopes of Mauna Loa. At quite a little distance from the geometric center of the lava field which forms the floor of this basin is the active fire-pit, marked during the day, as at Savaii, by a cloud of vapor, and at night by a pillar of fire.

The well-beaten trail to this center of activity leads down along the terraced wall of one side to the almost level floor of the main basin. In the strongest contrast to Savaii, Kilauea's lava field is remarkably even; indeed, the best areas of the former are far more broken than the most irregular parts of the latter. The surface undulates more or less, it is true, while here and there broken masses form hillocks and ridges, but the active vent has given forth the molten lava with comparative regularity. Since the middle of the nineteenth century enough rock has poured out into this wide basin to reduce the height of its vertical walls from more than eight hundred feet to about four hundred.

In December last, Kilauea was unusually active after a period of relative quiet. The fire pit (Fig. 9) is nearly circular in outline and its walls fall in two terraces to the small pool of molten lava, about two hundred feet below the natural level of the whole basin. Its general structure has varied more or less in past decades, as well as its degree of violence, but it has been a permanent center of eruptive activity for more than a hundred years, well deserving the native name of " Hale-maumau," the " House of Perpetual Fire."

Here as at Savaii the surface of the pool is in constant commotion, but the areas of incandescence are much restricted and run in parallel or forking lines. Cakes of congealed lava float between these lines, and when in their movements they reach the neighboring areas of greater activity, they are redissolved and their fragments are thrown into the air together with jets of more fluid lava. Photographs taken at night (Fig. 10) exhibit with great distinctness the major and minor areas of greater activity that form a network upon the surface of the whole pool.



THE RICE INSTITUTE.

THE PROGRESS OF SCIENCE

THE RICE INSTITUTE

In 1891 the late William M. Rice, a native of Massachusetts, who emigrated to Texas and there amassed a large fortune, selected a board of six trustees, and to them made over the sum of two hundred thousand dollars, the foundation of future philanthropies. At his further instance these trustees immediately incorporated under the name of the William M. Rice Institute, for the advancement of literature, science and art, and with the founder serving as a member of the self-perpetuating board undertook to administer the property of the institute until his death, and then—according to his wish, not before—to take up the organization of an institution of higher education open and free to the white inhabitants of Houston. When the donor died in 1900 the corporation was named as the residuary legatee of his estate; this bequest together with the original endowment and several generous gifts made during his lifetime make up the institute's present foundation of ten million dollars. Prolonged litigation established his will and the security of the foundation upon which the trustees were to begin the work of organization by placing its direction in the hands of Dr. Edgar Odell Lovett, called from the chair of astronomy at Princeton University. The task at hand was the planning of a non-sectarian institution which should look toward embracing eventually all the functions and activities of a university, but in which at the outset the interests of science should predominate; on the instructional side there was to be no upper limit, the lower limit being defined by the necessity of articulating with the best public high schools and preparatory schools of the south and the southwest; upon the investigational side where emphasis was to be laid, the direction of research in pure science and its applications was to be taken from the problems of material development peculiar to the south, commercial, industrial and agricultural; laboratories of biology, physics, chemistry, besides their use for purposes of instruction were to provide special facilities for research work by men of science, who should become identified with the institution. In effect, the terms of the charter, the will of the trustees, and every local consideration called for the establishment of a school of science, pure and applied, of university rank, wherein scientific studies were to be liberalized in an ever-increasing degree until with fuller means and ampler resources a university program, with all its complexities, might be entered upon.

By way of preparation for this work President Lovett made an extensive tour of investigation among the universities and higher educational establishments in this country and abroad, and upon his return attacked first the problem of planning a domicile worthy of the large endowment of the Rice Institute, and in keeping with its high aims and the character of its projected development. Striving to make a distinctive contribution to academic architecture in America, the trustees of the Rice Institute have boldly avowed their belief in the potency of a noble and impressive architecture as an inspiration to the youth who live and study within its shadow.

The solution of the problem was entrusted to Messrs. Cram, Goodhue and Ferguson, of Boston and New York, supervising architects of the institute,

who prepared a block plan indicating the most effective use of the three-hundred-acre campus lying along the boulevard extension of Houston's principal street, and designating the position of all future buildings; in those three comprised in the first construction—the Administration Building, the Mechanical Laboratory and the Power House—the architects have suggested a style of treatment which will be reflected in all future construction. This style is not one easy to characterize, for in it are borrowings from many southern types; reminiscent of the medieval work of Italy, southern France and northern Spain, the influence of the east and the new world's Spanish missions is not less apparent; the round Byzantine arch serves to impart a scholastic tone to the whole architecture which none the less retains a quality distinctively American and American of the southwest rather than of the north. In the blending of these southern types full advantage has been taken of local climatic conditions; bright, warm skies have prompted a freer use of color than would be hazarded in a severer climate; open courts bounded by cloister walks, while fostering an academic atmosphere, ward off the sun and give easy access to every wandering breeze from the south. Another local condition, the excellent quality of brick available had weight in the selection of a building material which would lend itself readily to the effects sought. The light pink brick of native clay seemed especially suitable to a local adaptation of the admirable brick work of northern Italy; this brick will be used, therefore, extensively and with pink Ozark marble will establish the prevailing color tone.

The Administration Building, so called because eventually its function will be the housing of the various administrative offices, will, at the outset, be put to more academic uses, and will contain besides the offices of the president, registrar and bursar, the great hall or assembly room, the library and a number of lecture halls, seminar and class rooms. Lying across the principal axis of the campus and facing the entrance from the Main Street Boulevard, the Administration Building is approached by a long driveway lined with stately trees and flanked by broad lawns. Its sallyport gives access to an inner court richly gardened and planted with cypresses, and walled in by the cloisters of surrounding buildings. As the principal building on the campus and the most conspicuous, it has been given a pronounced richness of color and finish; special pink tile matching the brick are extensively used in the face work; beneath the projecting marble cornice glazed tile of blue color form a frieze; and in the façades small shafts, columns and inlays of many colored foreign marbles discreetly accent the dominant color tone.

At some distance from the Administration Building and closing another long vista from Main Street Boulevard, the Mechanical Laboratory and the Power House, surmounted by a lofty campanile, form the extreme boundary of the proposed science group, and the nucleus for its immediate development. The laboratory itself contains on the first floor the necessary offices for professors in charge, two large laboratory rooms and a thorough system of lockers; upon the second floor two large drafting rooms and three lecture halls. Communicating with the laboratory in the rear, a large machine shop connects it with the Power House, which will supply light, heat, power and water to the entire campus.

The next construction will include two more laboratories in the planning of which, as in the Mechanical Laboratory, assistance was received from an advisory committee consisting of Professor Ames, director of the physical laboratory of Johns Hopkins University; Professor Conklin, director of the biological laboratory of Princeton University; Professor Richards, chairman

of the department of chemistry, Harvard University, and Professor Stratton, director of the National Bureau of Standards.

SCIENTIFIC MEETINGS AND SCIENTIFIC MEN IN THE MIDDLE WEST

THE National Academy of Sciences is meeting in St. Louis as this issue of the MONTHLY goes to press; the American Association for the Advancement of Science, with a number of affiliated societies, will hold its convocation week meeting in Minneapolis at the end of December. The National Academy has only once before since its foundation in 1863 held a meeting west of the Atlantic seaboard. This meeting was at Chicago in the autumn of 1903 and was fully as successful as the autumn meetings in eastern cities. The American Association for the Advancement of Science has been more national in the range of its meetings, having in 1901 gone as far west as Denver and in 1905 as far south as New Orleans. It met in St. Louis in 1903, in Madison in 1893 and in Minneapolis in 1883. Some of the affiliated societies which last year met with the association will not go to Minneapolis, there being scientific meetings in Ithaca, New Haven, Princeton and Pittsburgh. Still the number of scientific men in the middle west is now so large that a successful meeting at Minneapolis is assured. The University of Minnesota is one of the great state institutions; in recent years it has had a notable growth, and its future is assured by the immense fund which the state holds for educational purposes.

The fact that scientific men and their leaders are no longer concentrated on the eastern seaboard is indicated by the residences of the retiring and the incoming presidents of the American Association—President Jordan on the Pacific coast and Professor Michelson in Chicago. A statistical study of the origin and distribution of American men of science, recently made by the editor of this journal and published in the issues of SCIENCE for November 4 and 11, shows that the central and western states now possess a fair proportion of our leading scientific men and that they produce even more than they retain. The thousand leading scientific men of the country were selected by asking ten eminent men of science in each of twelve sciences to arrange those who had done research work in the order of the value of their work.

Of these leading scientific men there were in Boston 126, in New York 120 and in Washington 109. These three cities remain our chief scientific centers, but none the less there has been a significant westward movement in recent years. The list referred to has been made up twice, and it is possible to give the changes which have taken place in four years. In this short period the University of Chicago has gained nine men, the University of Illinois eleven and the University of Wisconsin twelve.

Even more significant is a consideration of the origin of the 238 men who have attained scientific standing between the compilation of the two lists and obtain for the first time this year a place among the thousand. Massachusetts has the highest birthrate of scientific men now as before, but it has sunk from 109 per million of its population to 85. The productivity has fallen in every one of the Atlantic states, from 47 to 36 in New York, from 42 to 17 in New Jersey, from 23 to 19 in Pennsylvania and from 38 to 13 in Maryland. On the other hand, it has increased in all but one of the north central states, from 36 to 74 in Michigan, which state now stands next to Massachusetts as a center for the production of scientific men.

Most of the north central states do not as yet retain the men whom they produce. Thus twice as many have been born in Michigan, Ohio and Indiana as reside in those states. Still the

fact that in the course of four years the states of Illinois and Wisconsin have increased their scientific men of standing by 27, while New York, New Jersey and Pennsylvania have lost 23, is significant not only of what has happened but also of what is likely to happen in the course of the next two or three decades. As civilization moves westward, these great north central states may be for a time the chief scientific center of the country; and not only this, for it is quite possible that they may become the chief intellectual and artistic center of the world.

THE DISTRIBUTION OF AMERICAN MEN OF SCIENCE

THE articles referred to contain a large mass of statistics in regard to the origin and distribution of our scientific men. The 238 men who have attained scientific standing within recent years fill the places left vacant by those who have died and of those who have failed to maintain their position among the thousand. Only one foreign man of science has come to this country of such distinction that he would surely have deserved a place on the previous list, whereas ten have returned to their native countries. Six women have been added, and the total number of women on the list is 18, two of whom are among the second hundred. Those who have obtained places on the list are nearly all between 30 and 45 years of age. There are none over 55; but one over 45 reaches a place as high as the fifth hundred. Only six are under 30, and this fact seems to indicate a lack of men of genius, who as a rule demonstrate their ability at an early age.

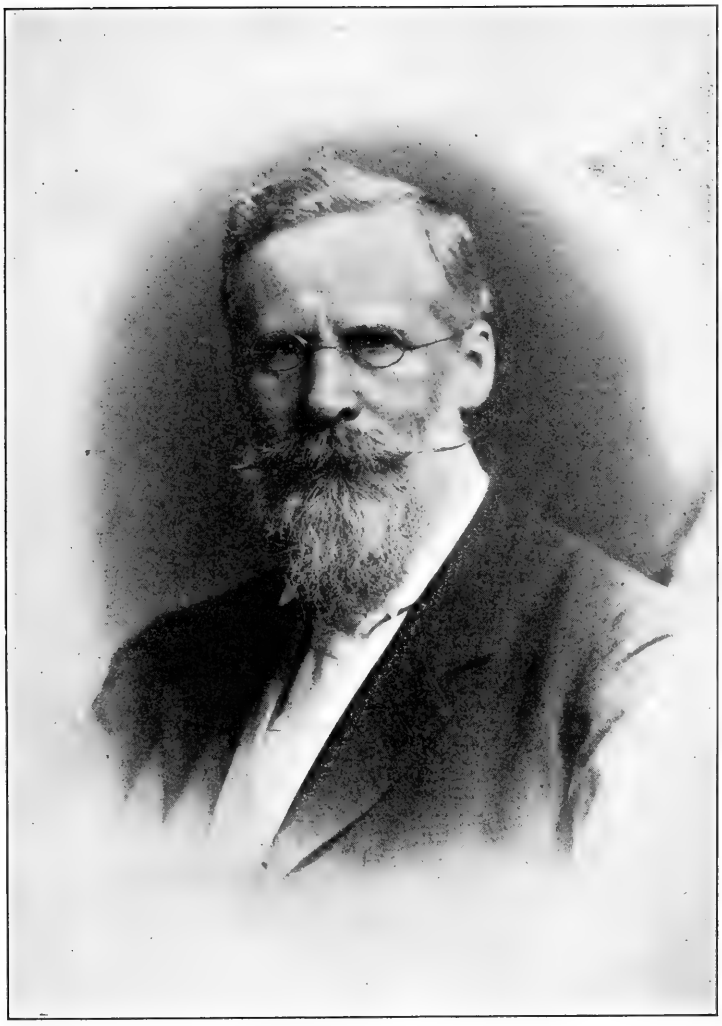
Harvard has a dominant position in the education of these men and in retaining them as instructors. It has given its bachelor's degree to 20 and its doctor's degree to 27, and 22 are on its teaching staff. Chicago stands next to Harvard, having an equal number of doctors and having 13 of the men among its instructors. Yale follows Harvard and Chicago both in regard to the men it has educated and the men it has retained. These three institutions are followed by the Johns Hopkins and Cornell in the number of degrees conferred and by Wisconsin and the Johns Hopkins in the number of instructors. The colleges of the eastern states have been less productive of scientific men than the technical schools or the colleges of the state universities.

There are 201 men still living who have failed to maintain their places among the thousand. Of these 49 reside in the state of New York. There, as in the other Atlantic states south of New England, the immense wealth appears to be unfavorable to scientific research.

The gain or loss of position of each man is known. Those under forty are likely to gain and those over this age are likely to lose. The average age of the 1,000 scientific men is 48 years; the average age of the first hundred is 54.8 years. The average age for the bachelor degree is 22.2 years and for the doctorate of philosophy, 28.4 years.

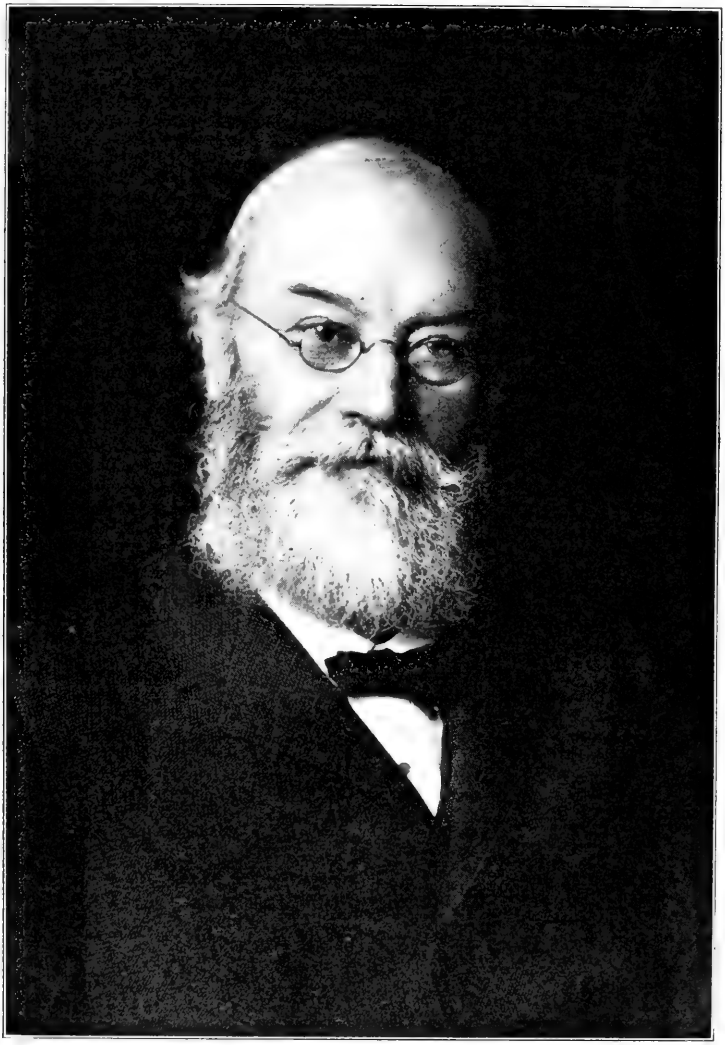
Three fourths of all our scientific men earn their living by teaching, about one tenth in the government service and about one twentieth by applied science. There are only eleven scientific men of standing who may be classed as amateurs, whereas in Great Britain this class is responsible for a considerable part of the research work which is accomplished.

Of our thousand leading scientific men 80 are at Harvard, 48 at Columbia and the same number at Chicago, 38 at Yale, 35 at Cornell, 34 at the Johns Hopkins and 30 at Wisconsin. One half of all the instructors at Clark are among our leading men of science, whereas in certain institutions there is but one in fifty. The institutions which stand the highest are Clark, the Johns Hopkins, Chicago, Stanford, Bryn Mawr, Harvard, Wesleyan, Case and Princeton. These institutions have at least one scientific man of



Sir William Crookes,

the eminent chemist, recently appointed a member of the British Order of Merit.

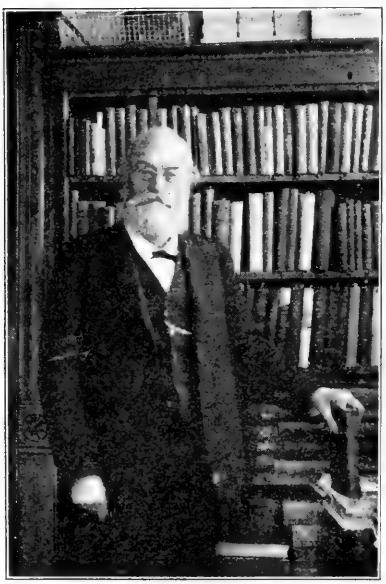


William Henry Brewer.

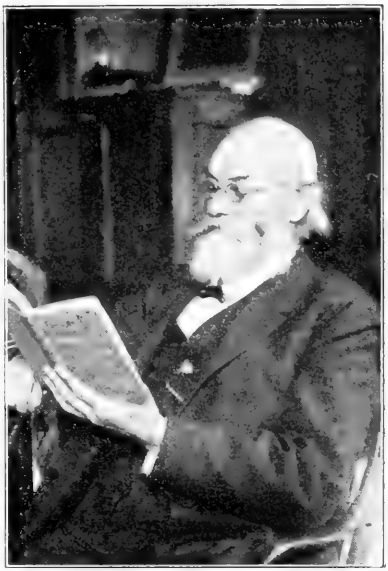
standing among each ten instructors. The five institutions that have the best record are of comparatively recent establishment; they have given a relatively more prominent position to science than the older institutions and have selected better men. At certain other institutions the ratios are: Yale, 10.6; Michigan, 12.3; Wisconsin, 13.2; Columbia, 13.3; Cornell, 16.5; California, 21.3; Pennsylvania, 25.2.

THE DEATH OF PROFESSOR BREWER

UNTIL the establishment of the Johns Hopkins University in 1876, Harvard and Yale were our chief centers of scientific research and productive scholarship. We are losing one after the other the men who gave distinction to these universities. Yale has mourned the death of Dana, Loomis, Newton, Gibbs, Marsh and Johnson, and now in the death of William Henry Brewer one of the few remaining links with the past is severed. He belonged to a generation and to a type of university professor which scarcely survive. The man of the world is now likely to be found in the university chair as elsewhere, leaving small space for the naïve and the unconventional.



PROFESSOR BREWER IN HIS LIBRARY.



PROFESSOR BREWER IN 1910.

Brewer was born on a farm eighty-two years ago; he graduated with the first class of the Yale scientific school; he studied with Liebig before studying abroad had become usual; in 1858 he became professor of chemistry and geology at Washington College. From 1860 to 1864 Brewer served on the California State Survey and was during the latter part of this period professor of natural science in the University of California. He always looked back with special interest to these years. He was associated with King, Whitney and others in exploring the Sierras, one of whose peaks is named in his honor. At this time the "Botany of California" was prepared.

In 1864 Brewer began his long service as professor of agriculture in the Sheffield Scientific School of Yale University. In addition to the work of his chair, he was indefatigable in investigation and exploration, in lecturing and in attendance at scientific gatherings, being rarely absent even to

the end of his life from the semi-annual meetings of the National Academy of Sciences.

SCIENTIFIC ITEMS

WE record with regret the deaths of David Pearce Penhallow, professor of botany in McGill University, and of Professor Melchior Treub, for twenty-nine years director of the Buitenzorg Botanical Garden in Java.

THE Nobel Prize in medicine for 1910 has been awarded to Dr. Albrecht Kossel, professor of physiology at Heidelberg.—For his researches on the determination of atomic weights the Royal Society has awarded the Davy medal to Dr. Theodore W. Richards, professor of chemistry at Harvard University.—The Harben Lectures of the Royal Institute of Public Health, of London, for 1912, will be given by Dr. Simon Flexner, of the Rockefeller Institute for Medical Research, New York.

ON the occasion of the recent celebration of the Mexican centenary a statue of Friedrich Heinrich Alexander von Humboldt, who more than one hundred years ago made his journey of research through Mexico, was unveiled.—It is proposed to erect in the new chemical building of the University of Michigan a bronze tablet in memory of Dr. Albert B. Prescott, for many years director of the chemical laboratory.—A drinking fountain has been erected at the Central Experiment Farm, Canada, in memory of Dr. James Fletcher, former Dominion entomologist and botanist.—The classification and cataloguing of the Simon Newcomb Library, the acquirement of which by the College of the City of New York has been announced, has been completed. This collection of 4,000 volumes and 6,000 pamphlets, was presented by Mr. John Claflin.

THE hospital of the Rockefeller Institute for Medical Research was opened on October 17. There were no special ceremonies, but a number of guests were present to inspect the hospital. At the same time it was announced that Mr. Rockefeller had given securities valued at $3,820,000 for the endowment of the institute, and that its organization had been completed.—At the celebration of the centenary of the University of Berlin Emperor William made an address, in the course of which he said that the occasion seemed to be peculiarly appropriate for a fresh movement towards the completion of Humboldt's aims. Humboldt's scheme required, in addition to the Academy of Sciences and the University, independent institutions for research. The plan had been communicated only to a small circle, but already sums amounting to between nine and ten millions of Marks, had been forthcoming. It would be the care of his government to see that the new foundations did not lack state assistance.

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